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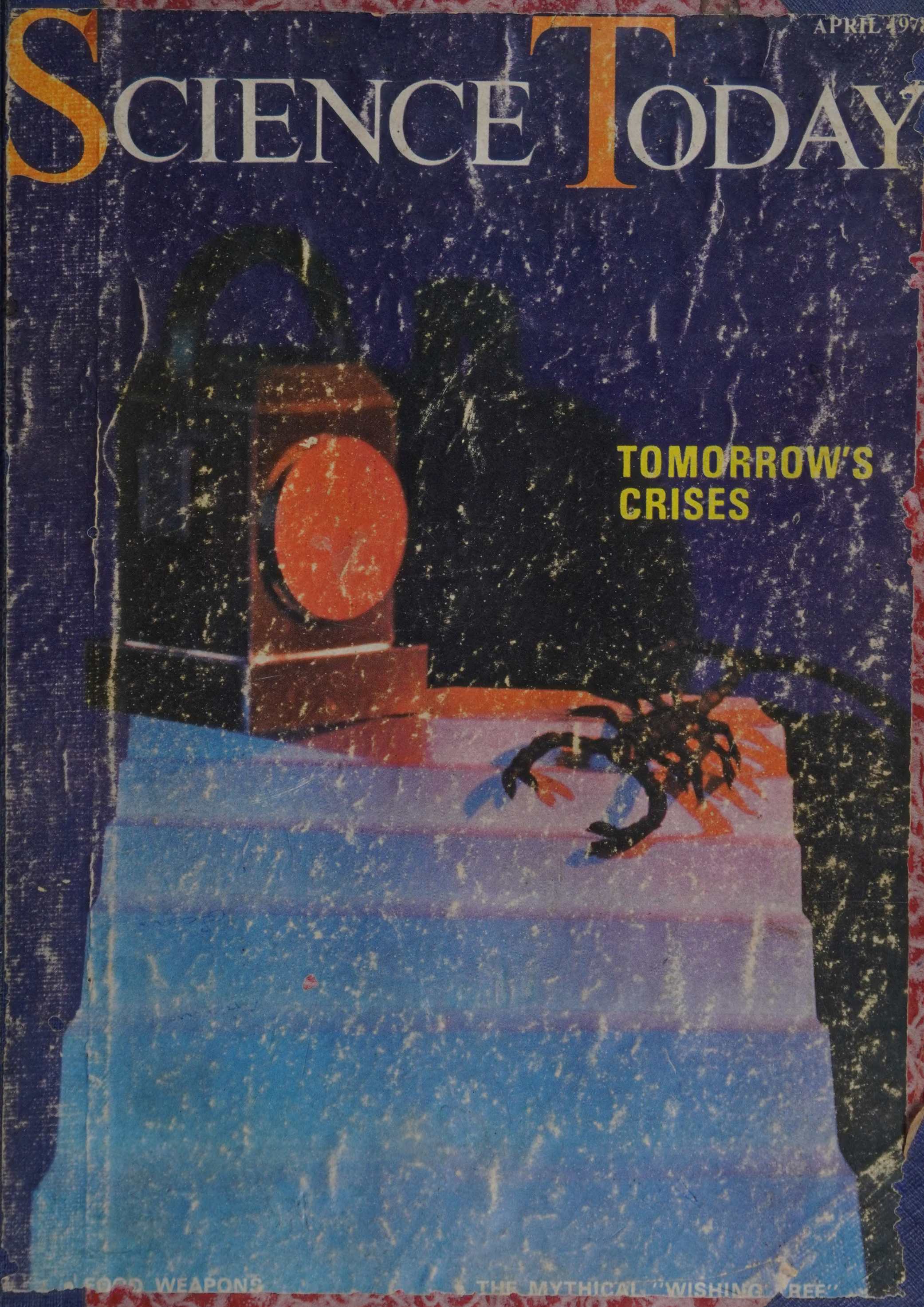

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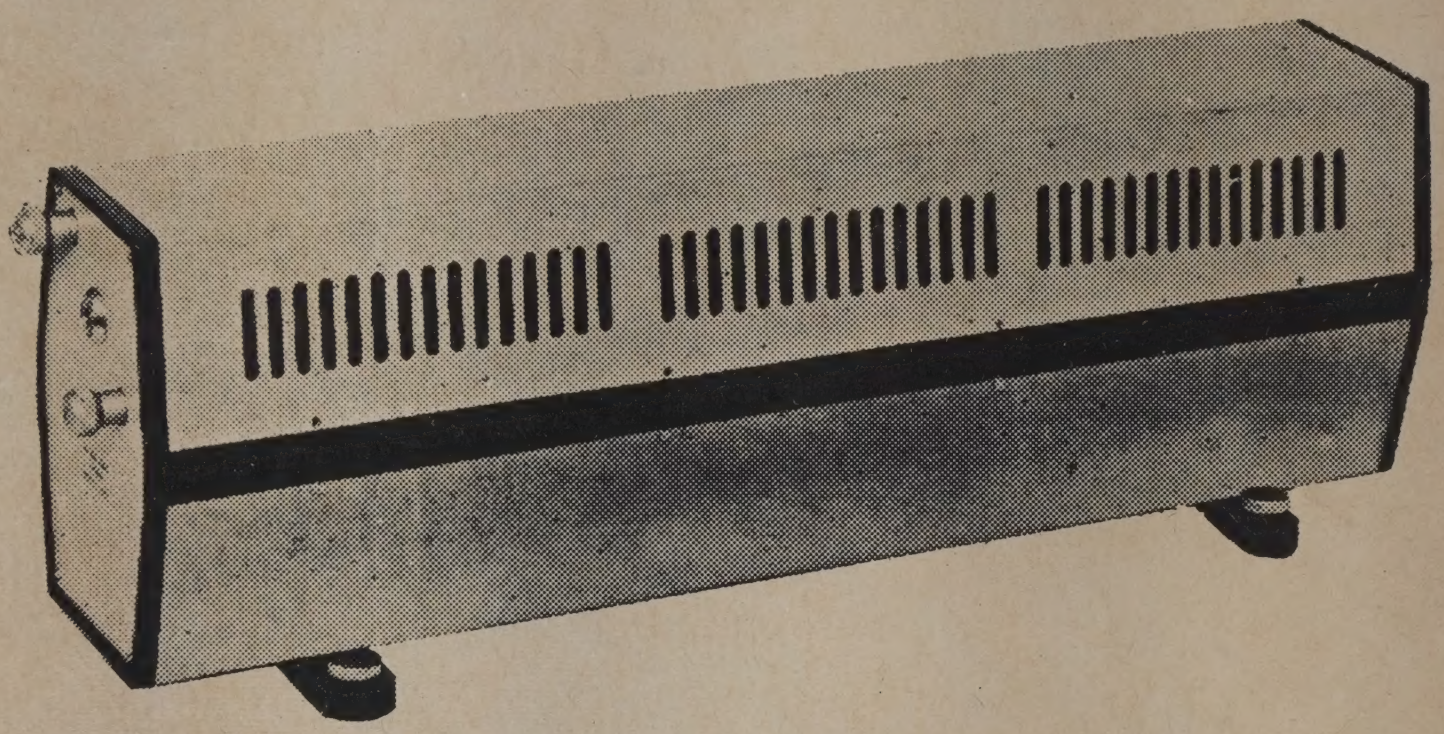

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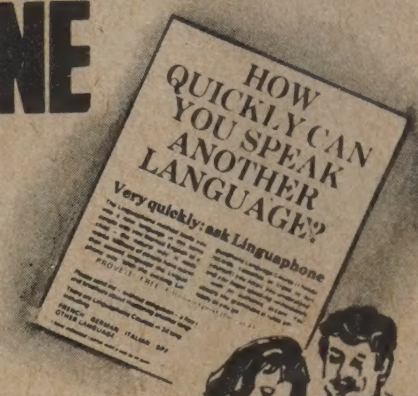

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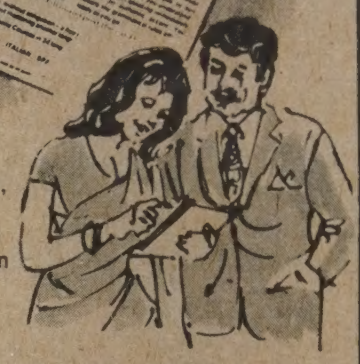

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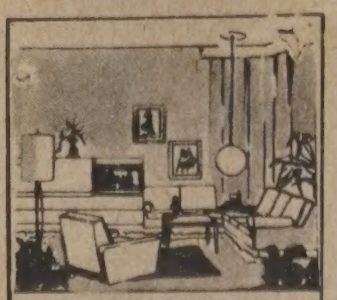

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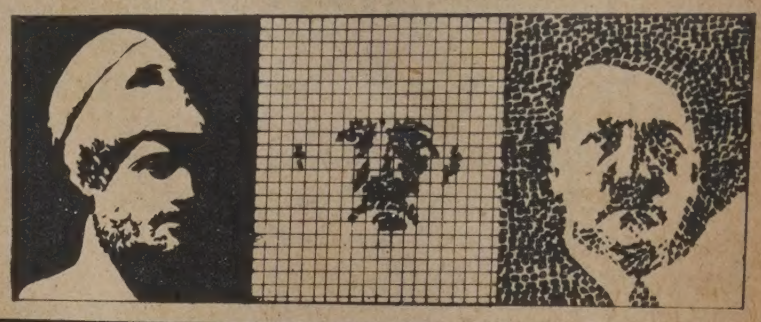

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LETTERS

s life possible on Mars?

The biological experiments performed y the Viking missions have not con-lusively proved whether life exists on Mars or not ("A Close Look at Mars", . S. Venkatavaradan, January 1977). Would it have been possible, and more seful, to fix a very sensitive microscope n the Viking, which could automatically lace the Martian soil on a slide and roject a high-powered image and vision or the observation of any movement of nicro-organisms?

The author states, "the Earth's present tmosphere is the result of pure chance. The oxygen is, of course, secondary and volved only after life evolved on Earth". races of oxygen and water vapour have lso been found on Mars. Could we infer hat at present the Martian atmosphere is omewhat similar to that on Earth before fe evolved on it? If so, is it possible o stimulate and hasten these conditions n Mars also, which may ultimately ecome favourable to the existence of life?

The low temperatures on Mars are omparable to those at the Arctic and the ntarctica. Thallophytes and bryophytes, ound in these regions consist of lichens, nosses and other dwarfed vegetation like nushrooms and black crowberry. This egetable life, including algae and some acteria, generate oxygen by photosyn-nesis, utilising carbon dioxide. And since arbon dioxide is so abundant on Mars, is possible to send a spaceship carrying nis vegetation under controlled conditions n the form of spores and cultures so that y chance, if it survives, it can generate xygen? Otherwise, can scientists think f exploding some kind of, say oxygen omb, either on the Moon or Mars which nay release hundreds of thousands of ons of oxygen, thereby creating condi-ions favourable to life?

W. A. SOLANKI
Librarian 'A'
Space Applications Centre (ISRO)
Ahmedabad 380 053

Dr. Venkatavaradan writes. **The points raised by Mr. Solanki are curious and thought-provoking. The idea of putting a very sensitive microscope on the Martian soil and projecting a high-power image for observing movements of micro-organism is really interesting. The life-detection experiments on the Viking biological laboratory are more general. Whereas the television cameras can detect movement of objects of a millimetre or less and, hence, can detect any mobile life down to that size, the detection of microscopic life is not limited to moving organisms alone. It includes non-moving microbial life also. Movement, even though a quality for some form of life, is not in itself a conclusive evidence for the presence of life on Mars. Fine dust particles (some of them electrically charged) of various shapes and sizes on Mars will also be moving, and they may give the false impression of life in motion. On the other hand, the three biological experiments mentioned in the article are quite specific for a wide variety of micro-organisms. They look for the presence of life processes like photosynthesis, nutrient assimilation and gas release. No doubt, the experiment suggested by Mr. Solanki could have been included in the mission but the number of experiments has to be limited for operational reasons. The idea was to get maximum amount of information with a minimum weight of the spacecraft.**

The atmosphere of Earth before life evolved on it (and the early Martian atmosphere) would have resembled the present-day atmosphere of Jupiter with a lot of methane, ammonia and water vapour; it is not necessary that it resembled the present Martian atmosphere. Both the atmospheres of Mars and Earth have undergone changes over billions of years. If there were to be no life on Earth, the atmosphere would have resembled the Martian atmosphere.

Regarding the third point, it may be that present-day conditions on Mars are favourable to some form of life such as algae. If some spores and cultures are sent to Mars, they may be able to survive and multiply resulting in an oxygen atmosphere by a feedback effect. However, the explosion of oxygen bombs, though a very imaginative idea, appears to be not practicable enough to make an appreciable change in the Martian atmosphere.

Of chillies and cancer

Let me add to your report "Chillies are good" (Science Shapes Life, January 1977) that chillies are often blamed to be a major aetiologic agent for cancer of the mouth. Studies conducted on animals in Bombay by Sirsat, Paymaster, Khanolkar, etc have proved that capsaicin, the active ingredient in chilly, when applied to the rat's palate, is capable of producing a condition very similar to human sub-mucous fibrosis — a known precancerous condition.

The incidence of cancer of the mouth in India is as high as 47 per cent (out of all cancer cases), whereas it is less than 3 per cent in European countries. Besides pan-chewing, a habit widely prevalent in India, the high consumption of red chillies should also be considered as a possible cause. Research is being done on oral cancer in Trivandrum, Bombay and Adyar (in Madras).

DR. K. NARAYANAN UNNI
Research Officer
Indo-Danish Cancer Project
Dental Wing, Medical College
Trivandrum 695 011

Why do bridges collapse?

By and large, Mrs. S. A. Bhagat has restricted her article ("Why do bridges collapse?", December 1976) to road bridges and their design and maintenance. The Railways have a variety of bridges, and they are looked after by a specialised organisation which has laid down a strict programme for inspection and maintenance of the steelwork as well as masonry in the substructure. The maintenance includes a five-yearly thorough technical inspection of girder work and three-yearly (or even earlier) cleaning and greasing of bearings, besides painting of the steelwork to stringent specifications. All these are carried out under the supervision of fully trained and qualified bridge inspectors and bridge engineers.

Further, the original completion drawings which include all the basic data — waterway, depth and type of foundations, highest flood level, lowest water level, type of strata, area of catchment, agency of construction (departmental or through contractors) — are preserved. Majority of the railway bridges are over 90 years old and the engineering department, even today, possesses the *original completion drawings* prepared in 1886 or even earlier. And there is a constant drive to conduct research in the structural stability of the bridges before allowing any higher loading, either for an engine or a new wagon, by using sophisticated methods such as computer analysis and oscillographs.

L. G. PATWARDHAN
"Indu Bhuvan," 31, Prarthana Samaj Road
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I agree that bridge failures have to be published in order to prevent others from making similar mistakes. But mere publishing of mistakes is not enough. One has to find the reasons for the failures. And, though Mrs. Bhagat has reported many failures, she has given alternatives and suggestions only for a few.

Mrs. Bhagat has stated that "the design engineer assumes that the geometry of the bridge remains the same before and after loading". This is not true. Actually, with the advent of computers and numerical methods, finite element nonlinear programs have been developed which can be used to analyse and design structures having material and geometric nonlinearities. Large deflection analyses of several box girder bridges have already been attempted and reported. Partial fixities can also be tackled using these programs.

There is a reference to buckling failure in the article, but no examples are given. I would like to mention the failure of the Quebec Bridge during construction in 1907. One more failure which is of interest is fatigue failure. One such failure occurred in 1953 in the lower chord member of the stiffening truss of the Manhattan Bridge in New York.

N. SUBRAMANIAN
47, North Usman Road
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I would have appreciated a deeper approach to the subject. It would have been helpful if the article had dealt with the strengthening of worn-out bridges also. Finally, I hope you would publish articles on civil engineering more often than on fundamental sciences.

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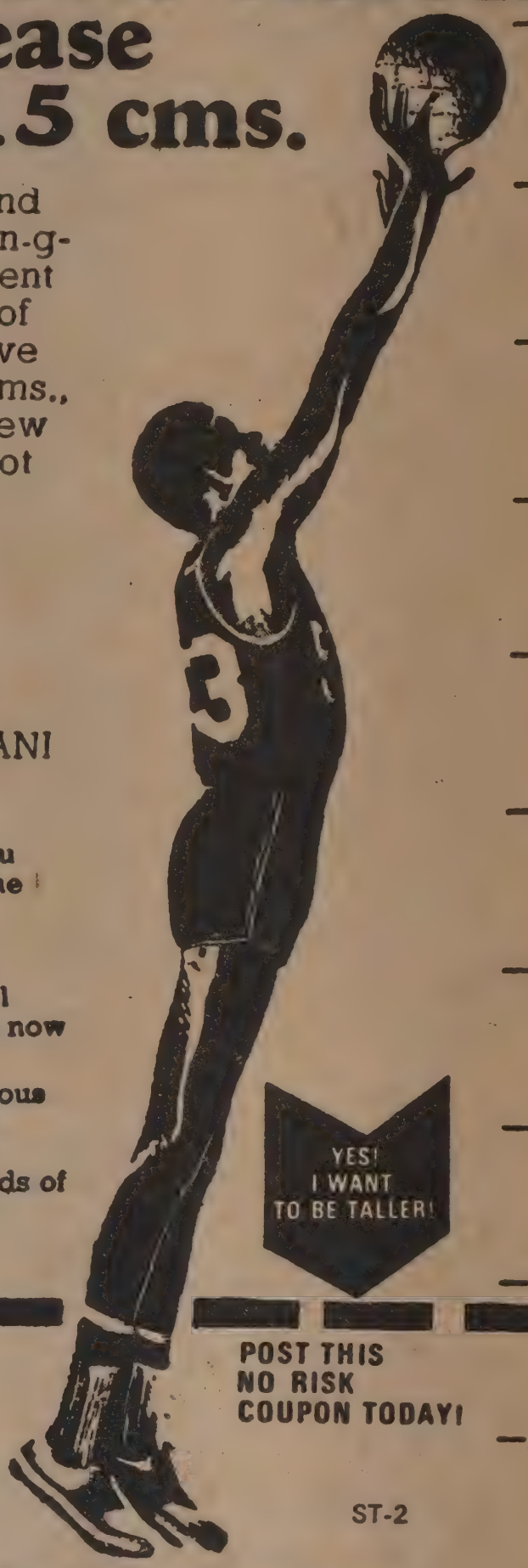

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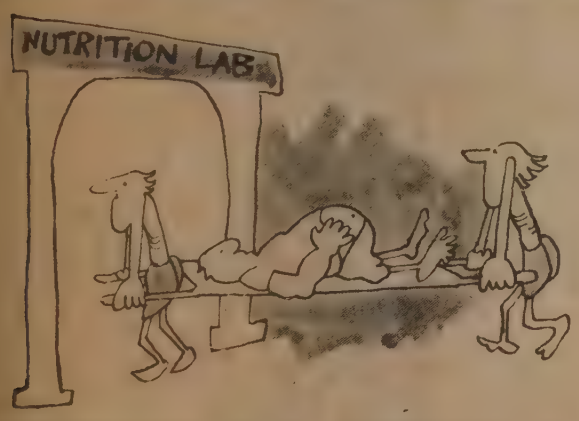
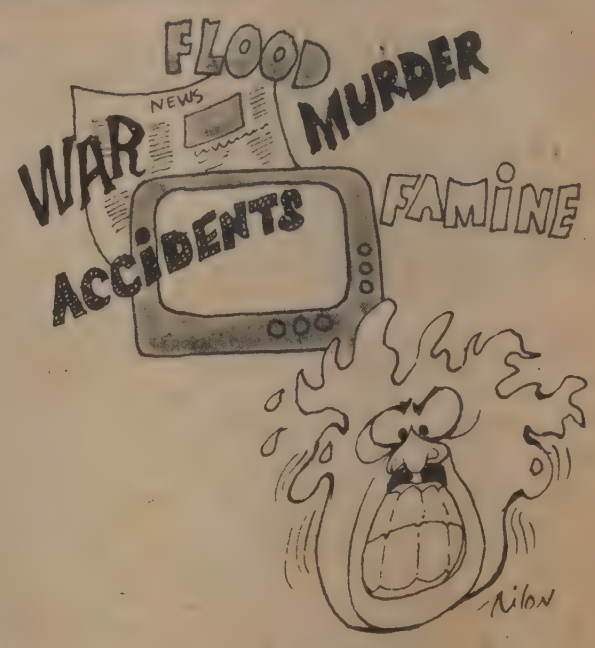
Like undernutrition, overnutrition, too, increases susceptibility to certain diseases, reduces productivity and the life-expectancy of the individual. Besides, if it could be prevented, the surplus could be diverted elsewhere. About one-third of the world's annual grain produce is used for fattening live-stock. Moderation in consumption of fatty live-stock could help to modify the terms of the global competition between the rich and the poor for available food and agricultural resources. According to a report from the World Watch Institute, *The Two Faces of Malnutrition*, only Norway and Sweden have moved towards systematic health-oriented nutrition policies.



The report also suggests that right transport policies could help to increase physical exercises — like the laying of bicycle paths instead of car parks — so that the obese could work off some of the cholesterol (and save precious fuel?). The problem of overnutrition is becoming almost as great as that of undernutrition.... Few potential social policies promise so many benefits as the decision to alter the "affluent diet", the report concludes.

SOCIAL IMPACT OF NEWS

In psychological terms, action and reaction are not opposed. Good news make a person more co-operative; bad news promotes competitiveness. As an experiment, New York psychology students dropped wallets and waited for them to be returned. On an average, 45 per cent of the students got back their 'lost' property.

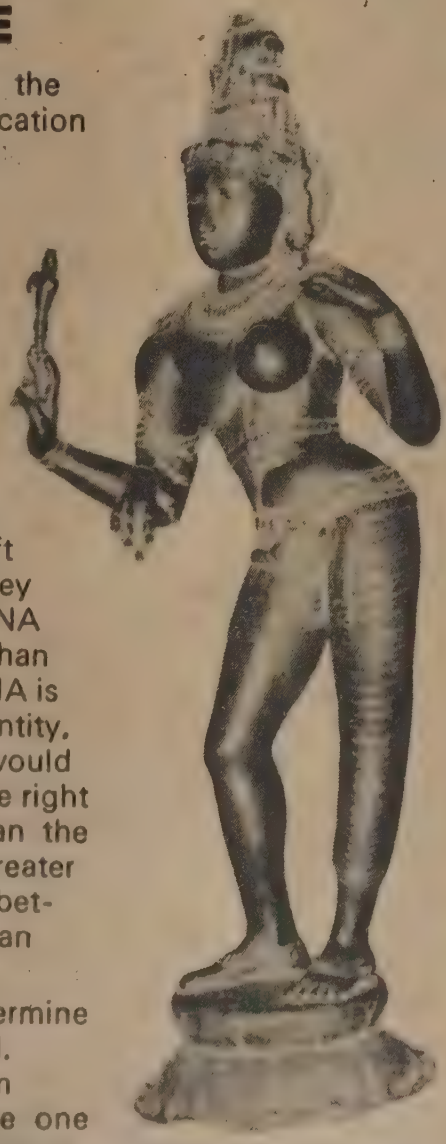


But none of the wallets lost on one particular day, 4 June 1968, was returned. The following night, Robert Kennedy was assassinated. With this bad news, the 45 per cent of honest folk apparently got disgusted enough not to trouble themselves with locating the owners of the wallets they had found.

Researchers, S. M. Holloway and H. A. Hornstein of the Columbia University, have since then tried to establish a link between news and social behaviour. They found that bad news does, indeed, break down normal social bonds. In an experiment, groups of subjects listened to music over the radio. The programme was interrupted by news reports. One group heard a good news about a clergyman donating his kidney to save a man's life. Another group heard a report about a clergyman killing a 72-year-old sculptress. The news reports had been faked without the subjects' knowledge. Later, the subjects were questioned about moral and ethical disposition of people in general. As expected, those who heard the good news expressed a higher opinion of people than those who had heard the bad news.

RIGHT: MALE, LEFT: FEMALE

The ancient Greeks believed that the position of the fetus (in the womb) determined its sex. A right-side location meant male and a left one, female. The concept of right and maleness and left and femaleness is to be found in various cultures. The Indian palmists, for one, look at a woman's left hand and a man's right. The mythological *Ardhanarisvara* has the right-half of a man and left-half of a woman. Myths and mystics apart, scientists are now discovering a definite right-left orientation in sexes, according to an article in the *New Scientist*.



Ardhanarisvara, early Chola, AD 11th C, Tiruvengadu

Dr. Ursula Mittwoch, Galton Laboratory, University College, London, and her colleague, Dr. David Kirk, compared the development of the right and left gonads (sex gland) in normal human fetuses. They weighed the gonads and estimated their protein and DNA contents. They found the right gonads were heavier than the left and contained more protein and DNA. Now, DNA is present in fixed amount in cells; and a greater quantity, therefore, implies a larger number of cells. This would mean, more cell divisions must have taken place in the right gonads. Generally, the testes contain more cells than the ovaries. This could imply that the right gonads have a greater potential of developing into testes. And the difference between the two sides was more marked in the ovaries than in the testes.

In normal human beings, when chromosomes determine the sex of the offspring, no lateralisation is noticed. But in hermaphrodites, the chromosomal mechanism usually breaks down. As a result, the person may have one ovary and one testis or one or two ovotestes. In hermaphrodites, Mittwoch found, the right gonads tended to become testes while the left ones tended to become ovaries. (In normal individuals the chromosomal control masks this tendency.)

In another study (of fingerprint ridges), it has been found that the right hand has more ridges than the left and, in general, men's fingers have more ridges than women's. The difference here is attributed to chromosomes.

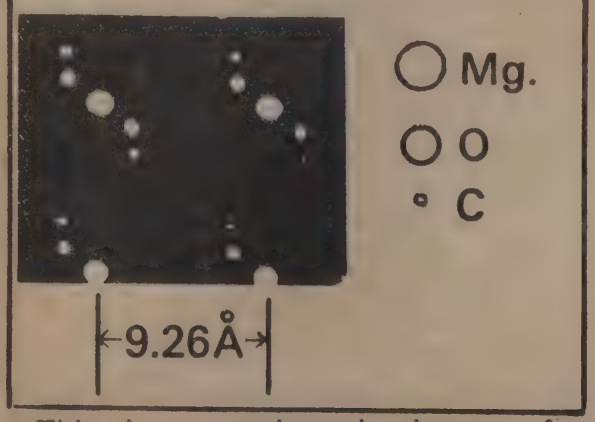
The Greeks thought that the side of the father or mother influenced the sex. (In case of the father, it was thought the right testis gave rise to males and the left to females. In the mother, the position in the womb was believed to affect the sex.) However, though these beliefs may not be true, the study suggests that the embryo itself shows a degree of lateralisation according to its sex.

FIRE-RETARDANTS CARCINOGENIC ?

Fire-proof fabrics have their advantages, no doubt. But, according to a report by Allen Blum and Bruce Ames, biochemists at the University of California, Berkeley, USA, the fire-retardant chemical, tris (2, 3 dibromopropyl) phosphate, may be carcinogenic. Extracts from treated fabrics had been shown to be mutagenic in bacteria by scientists of the US Environment Protection Agency and the New York Medical College.

Ames and Blum say that, even if the chemical may not cause cancer in man, it might induce genetic defects. The chemical might be absorbed through the skin, according to some studies. The National Cancer Institute (USA) is now investigating whether it is carcinogenic, too. (Many mutagens are not carcinogenic.) However, according to Ames and Blum, the risk involved in its use far outweigh the benefits. The chemical is used in children's nightwear and many other fabrics, carpets and plastics.

PEERING THROUGH CRYSTALS



This is an enlarged picture of a magnesium bromide tetrahydrofuran complex showing the atoms in the crystal section. This technique of crystallography has been developed by a team headed by G. W. Stroke at the State University of New York, USA. Two full unit cells of the crystal and parts of two others are visible. The largest spots are magnesium atoms, the smallest ones (at the extremities) are the carbon atoms and the medium-sized ones between these are the oxygen atoms.

Being able to look through crystal structures will "provide the scientist with a new tool to help unlock the mysteries of chemical and biological functions of molecules, for example, the functions of antibiotics and the body's natural immunological defences". Other possible applications will be in the fields of geology, material sciences, molecular biology and medicine.

The new photographic method involves probing by X-rays, optical computation and holography. First, the relative sizes and locations of the atoms in the crystal are ascertained (in a digital form) by X-rays. This information is converted into a hologram by computer, and the hologram is then treated like ordinary photographic holograms. When illuminated by lasers of the proper frequency, a three dimensional image is formed pinpointing the locations of the atoms.

THE BEE'S ELECTRIC COMMUNICATION

Bees scout long distances in search of food. They navigate by polarised light. And when they come back to their hive, they tell the others where to find the flower(s) by means of set dances which are already well known. However, now bees have been found to communicate by electrical signals.

A bee leaves its hive with a slight negative charge. As it flies to and fro from flowers, it picks up static electricity and returns to the hive with a positive charge. The electric field potential built up between the flower and the insect may be of the order of 1·5 volts and this may help to attract pollen grains. Eric H. Erickson of the Agricultural Research Service, Madison, USA, who discovered the electric charge on the insect and its possible role in pollination, speculates that it might also be used in the communication of the insects, since the charge built up depends on the distance covered and the amount of solar radiation.

Impending storms also affect the build-up of charge and make the bees irritable. Erickson suggests, electricity might also be involved in some aspects of the bees' behaviour.

ASCENT OF THE SNAKE'S HEART

In water snakes, the heart lies somewhere in the middle of the body. In arboreal (tree-dweller) snakes, the heart is nearer to the head.

The position of the heart is important in regulating blood flow to the brain. In arboreal snakes, which stay in a vertical position more often than the water reptiles, the higher location of the heart ensures blood supply to the brain.

Two scientists, R. S. Seymour of the University of Adelaide, Australia, and H. B. Lillywhite of the University of Kansas, USA, analysed nine snake species. In arboreal species, the blood pressure was 74 mm of mercury. In the aquatic snakes, the blood pressure was just about 22 mm of mercury. The scientists conclude that changes in blood pressure regulation might have evolved as a result of the changing life-styles of the reptiles.

RECYCLING ALUM

Alum is used as a coagulant to remove suspended material in water. Once used, it is disposed off. This, according to a Michigan State University civil engineer, David A. Cornwell, is a waste of v aluminium which can be easily rec He has developed an easy recovery p The alum sludge is partitioned kerosine/alkyl phosphate solutio aluminium of the alum passes in kerosine, and this can be treate sulphuric acid to produce alum, the kerosine for reuse.

NEW TYPES OF MOONS

The natural satellites in the oute system come under five categorie classification is according to their composition: rock, evaporate salts, ice, methane ice or a mixture of i some neutrally reflective substan categories are defined by their reflectances in four near-infra red known as H, J, K and L (1·60, 1·2 and 3·5 microns, respectively).

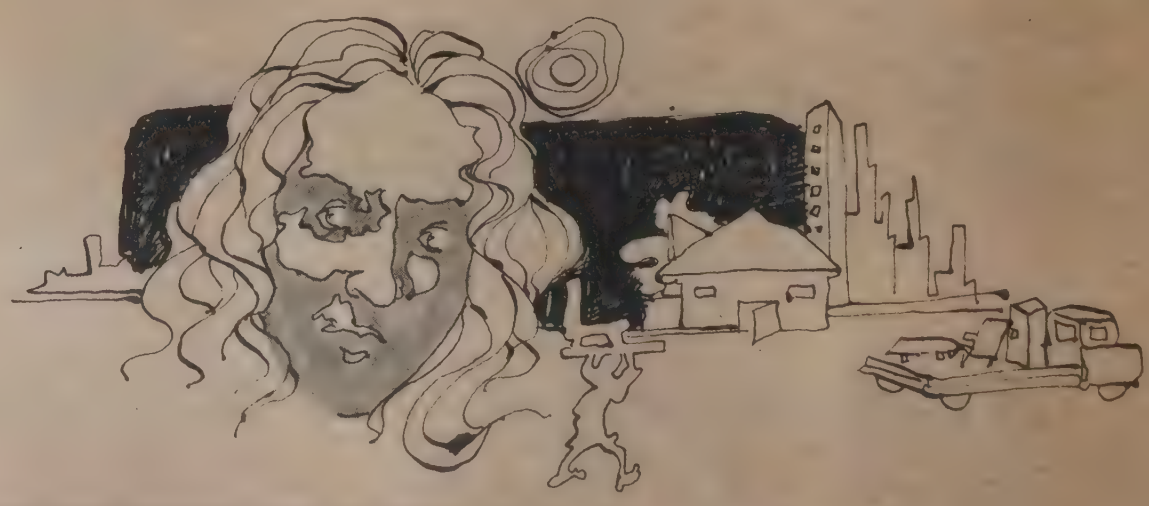
A research team from the Univer Hawaii — D. P. Cruikshank, C. B. and D. Morrison — says there may another type of moon whose composition is not yet identified; its IR signature places it somewhere be the rock and the ice-and-som mixture.

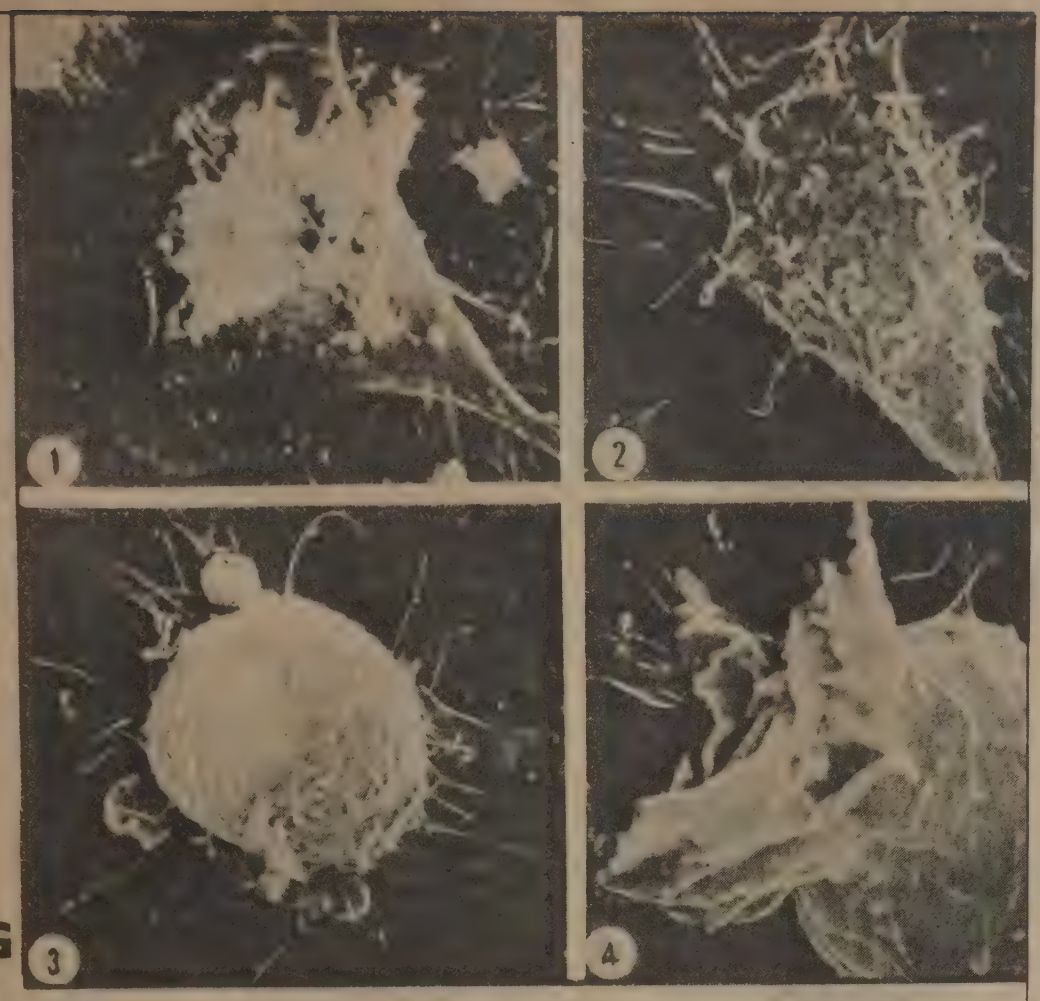
Moons belonging to this catego those of the Saturn (Hyperion), U (Titinia and Oberon) and Neptune (T These do not show J, H, K signatu water, methane and ammonia ice. are characterised by neutral refle between J and H and rapidly decr reflectance at K and L. Identifyin surface composition of the new cl moons will provide vital clues t refinement of models of planet satellite formation from the solar neb

MOVING HOUSE? HOW OLD IS YOUR CHILD?

What's the connection? Dr. Michael Inbar of the University of Haifa, Israel, has found a strong one. After conducting a survey, Inbar found that, between the ages of six and 11 years, a child is most affected by any sudden upheaval in his or her environment. Looking back into the case histories of several 20-year-olds, Inbar found that the subjects had showed a marked decrease in mental capabilities if their homes had been shifted during the vulnerable period. "Moving seems to have hurt their ability to cope in school environment, and seems to have lowered their general ability to think and rea intelligently", says Inbar.

Beyond this age range, the effe are fewer; the below-sixes and ov 11s are better at voicing their reactio In the vulnerable age group, t children are more reticent. This peri of life is of vital importance in develo ing social interaction skills. When ups by a change of residence, the children a less able to relate to people and their co munication skills suffer. These effe are usually long-lasting. Inbar sugges that children of this age-group mig also be susceptible to other changes.





TRACING CANCER

Normal cells have a specific life-span. However, once they become cancerous, they multiply unlimited till the host dies. What's the mysterious mechanism? Allan R. Goldberg and Eugenia Wang of Rockefeller University, USA, have traced the stages in the transformation of a normal chick embryo cell into a cancerous cell.

They infected chick embryo cells with the Rous sarcoma virus. This virus has a gene, known as the SRC, that causes cancer in chickens. They observed the changes the virus brought about in the cells by means of scanning electron microscopy immunofluorescence and transmission electron microscopy. After adding the virus to the cells, the temperature was adjusted so that the virus induced malignancy.

Wang and Goldberg studied the changes in the shape of the muscle protein, actin, in cell protoplasm. The actin microfilaments did not show any change till the second stage. By stage three, their numbers showed a marked reduction and some of them got mixed with the cell membranes. Simultaneously, the cell surface, too, showed changes. The scientists speculate that these changes are probably brought about by a protein produced by the SRC gene. Once the cell shape is altered, it might not interact with its neighbours nor reproduce normally.

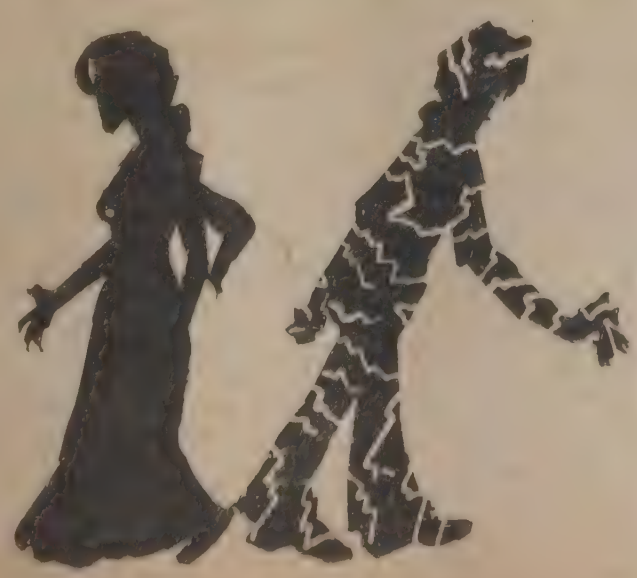
The photographs above show the stages of transition. In photograph 1, flower-like membrane ruffles, formed by extension of free cell surface, appeared in the nuclear region in the first stage — between one and two hours after infection. The cell, however, retained its normal shape. In the second stage (photograph 2) — three to 12 hours — long cellular processes were withdrawn into the nuclear region leaving several retraction fibres around the margins of the cell. The nuclear region became elevated and the cell surface was covered with finger-like projections. The retraction brought about a change in the cell shape.

At the end of the second stage, the cell had become more or less spindle-shaped (photograph 3) and in stage three (photograph 4) — between 12 and 24 hours — the shape became completely circular and the cell surface was covered with blisters ; the retraction fibres and finger-like projections had considerably reduced. The ruffles, of stage one, sometimes reappeared.

UNEQUAL LOVERS

Men, according to a report in a recent issue of *Behavior Today*, fall in love more often than women do ; they also find it harder to break up a serious relationship. Charles Hill Zick Rubin and Letitia Anne Peoplane, two Brandeis University, USA, psychologists, have conducted several surveys. Rubin says, men think falling in love is enough to start a relationship.

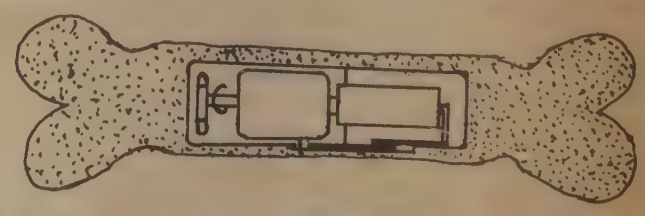
On the other hand, he found, women fall out of love more easily than men do. That's because they set higher standards for the quality of relationship and are, thus, more sensitive to the problems that arise. Rubin also found that in the event of a break-up of the affair, the couple would remain friends if the man called off the affair rather than if the woman signalled a stop. A woman finds it easier to redefine a relationship. According to Rubin, " Women learn in our society to better control and manage their emotions and to be in better touch with them. Men learn to keep their emotions in check. This creates special differences for them in ending relationships."



DOG AND BONE

Georges Richard, a Frenchman, has patented a toy for dogs. The bone-shaped gadget vibrates when squeezed (bitten). When the surprised canine drops it, the bone remains still. This prompts it to reinvestigate, and lo! the bone comes back to life.

How does it work? The plastic bone contains an electric motor with an unbalanced wheel, a battery and a switch. The switch, consisting of two metal pieces, turns on whenever the bone is pressed. This activates the wheel, which makes the bone shake erratically, and vibrate. The moment it is dropped, the switch turns off.



ALCOHOL IS BLINDING

Alcohol in small quantities relaxes the drinker. In larger doses, it affects the mental, muscle and motor abilities. The " one for the road " is often the cause of traffic accidents. According to Anthony J. Adams (an optometrist) and colleagues at the University of California, Berkeley, and the Pacific Medical Center, San Francisco, it's not just the dulling of the

senses that cause traffic accidents. Alcohol affects vision, too. Even moderate drinking produces changes in identifying and tracking moving objects, in recovering from glare and in distinguishing between some colour shades.

Adams's team found glare recovery, which in normal individuals takes 20 seconds, took 20 to 30 per cent longer after the person consumed a few drinks. During this period, a person normally experiences partial blindness. While driving, glare from oncoming cars, which is scattered by the windshield, is no small problem. And as for identification of moving objects, the faster an object moves, the more difficult it becomes for the inebriated person to focus on it.

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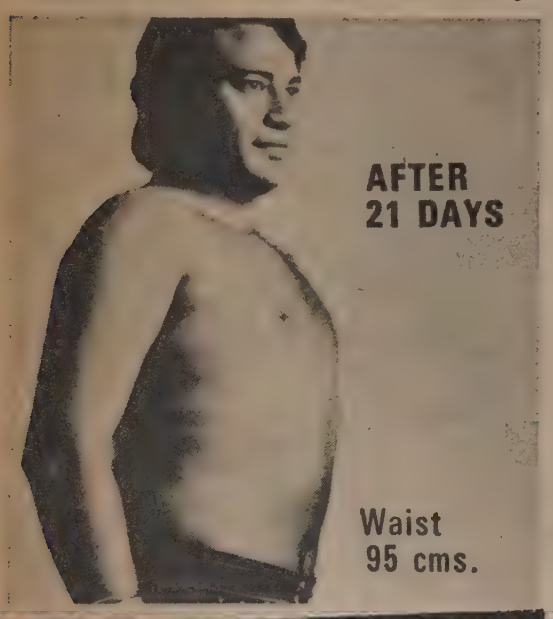

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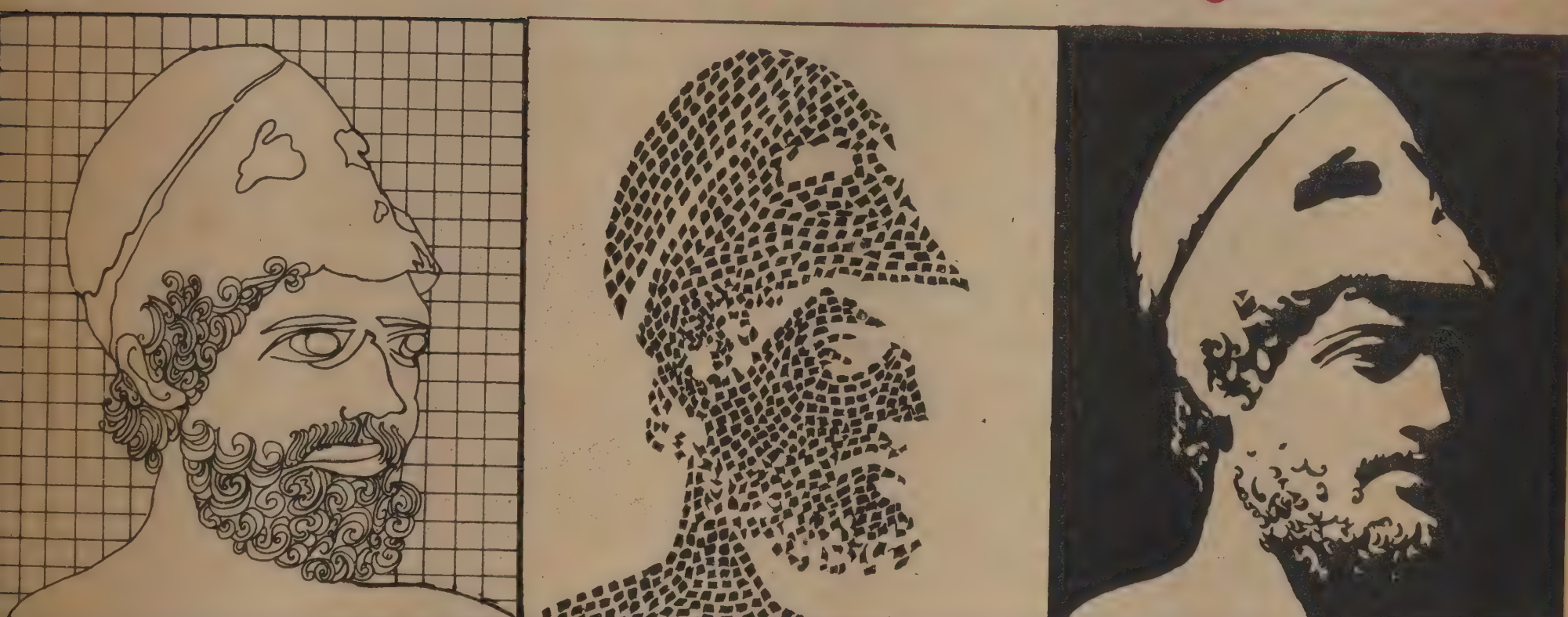
GENETIC ENGINEERING TECHNIQUES



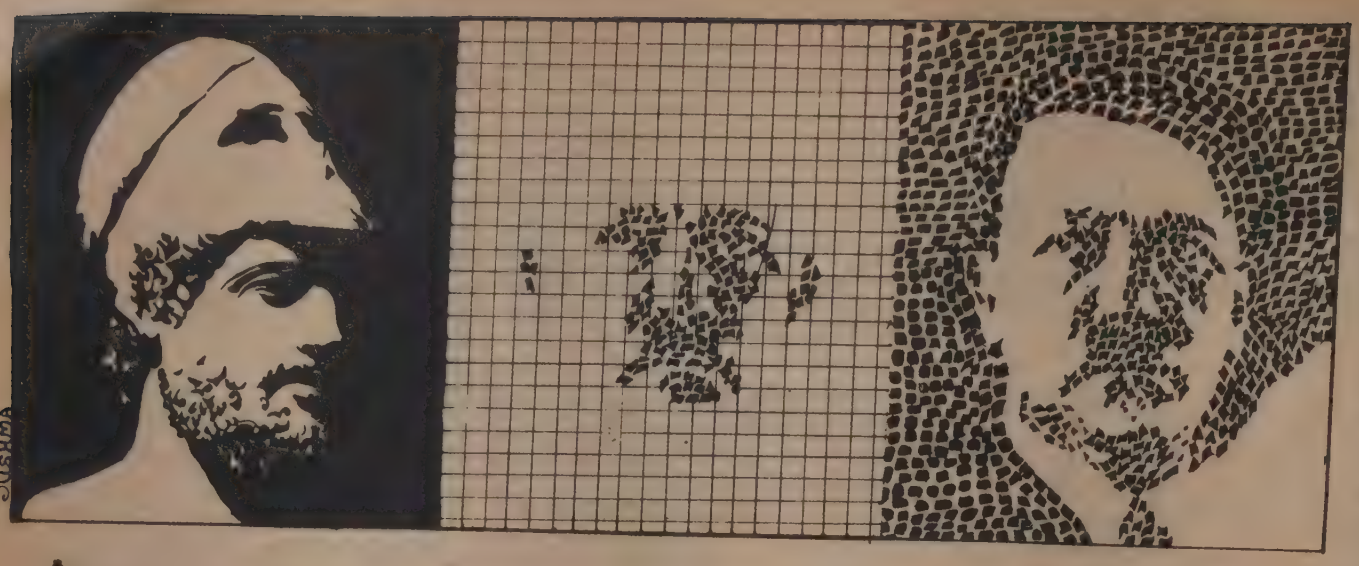
Geneticists call them the magazine illustrators' short-cut visuals — a sculpted Greek god-head and the face of a 20th century monster known as Hitler — in the depiction of the good and bad in genetic manipulation. Reality, they say, is far behind. But, not far enough, as witness the recent cautionary calls sounded by scientists themselves. Be it for the good or the evil, the basic idea is to 'transplant' the desired genes. How can this be done?

Genetic engineering is a much debated subject today. Briefly speaking, it is concerned with attempts to modify a cell's genetic make-up by the introduction of foreign genes. And, as such, it raises immense possibilities — both beneficial and harmful to mankind.

On the positive side, it offers a new and challenging approach to the cure of many hereditary diseases in a permanent manner. The introduction into a bacterium of genes coding for commercially important proteins such as insulin may lead to the creation of living factories producing proteins that are otherwise difficult to obtain. Perhaps, more important, genetic engineering techniques offer agriculturists the possibility of the introduction of nitrogen-fixing genes in cereals. This would reduce our dependence on the expensive artificial fertilisers and go a long way in solving the pressing food problem. There is also the exciting possibility of producing plants and animals of totally novel design.

On the negative side, there are fears that the manipulation of genes may introduce new kinds of diseases and organisms containing dangerous genetic elements which mankind may not be able to counteract; these diseases may spread far and wide before any effective measures could be undertaken. Many drugs such as antibiotics, which have helped man to fight bacterial diseases, may become ineffective, for all kinds of bacteria may acquire resistance to antibiotics. There is also the fearsome possibility that the technique may be misused by politicians to serve their own ends to create Frankenstein-like monsters or Hitler-type children.

But, the above are, at present, just wild fantasies. A lot of technical advances have, no doubt, made possible the introduction of genes from one organism to another, but we are yet very far from creating tomorrow a superman, or a beauty queen of unsurpassable charm. A lot of patient research embracing many fine details is necessary before we learn to ensure that genes are isolated from one organism and integrated safely into another in a desired way. Some progress has already been made, though, in this direction and the hope is that the efforts would be



accelerated. The science of genetic engineering is, thus, still in its infancy, but its enormous potential impact, both in pure research and commercial exploitation, is already apparent.

The need for genetic engineering arises because a mutation may render a gene of an organism functionless, and, thus, make the whole organism defective. Or, the organism may be normal, but it may not possess a particular gene desired by man. Basically, what the genetic engineer does is to introduce, and permanently integrate, a foreign molecule of DNA into the defective cell of the organism to correct the defect without in any way degrading and altering the other normal functions of the organism. Probably, in some special situations, he must also be able to remove some undesirable stretches of DNA.

Before proceeding any further, however, let us briefly review how the genetic information is coded in living organisms. The cell is the basic unit of life. Almost at the centre of a cell, there is a round or ovoid body called the nucleus and within the nucleus there are two sets of homologous chromosomes, one of which we inherit from the father and the other from the mother. Each chromosome contains DNA (the fundamental hereditary substance) — a single long molecule running almost the entire length of the chromosome and made up of as many as a thousand genes in a contiguous fashion. The DNA molecule itself is made up of four kinds of bases attached to a sugar-phosphate backbone. The life's code resides in the order of the four bases — adenine (A), guanine (G), cytosine (C) and thymine (T). In reality, DNA is a double-stranded molecule in the form of a helix with the bases of one string held to the bases of the other by hydrogen bonding in a specific manner: A pairs with T and G pairs with C (Fig. 1). The molecule also contains an inherent mechanism for self-duplication. However, when DNA does not replicate, smaller stretches of it may synthesise molecules known as messenger RNA (mRNA) which carry the code of life from the nucleus out into the cytoplasm. Here, the messenger RNAs, with the help of ribosomes and related machinery, synthesise enzymes or other protein molecules (Fig. 2).

Transformation

The first crucial experiment which led to the discovery of DNA molecule as the hereditary material was indeed a momentous one. The experiment was performed in the 1920s by an Englishman, Griffith. He found that extracts of the heat-killed virulent pneumonia bacteria (*Pneumococcus*) injected into mice together with living non-virulent bacteria turned the latter into virulent bacteria as if a real hybridisation had occurred (Fig. 3). Although, not recognised as an experiment in genetic engineering then, subsequent developments have made it clear that it was indeed the first successful case of genetic manipulation.

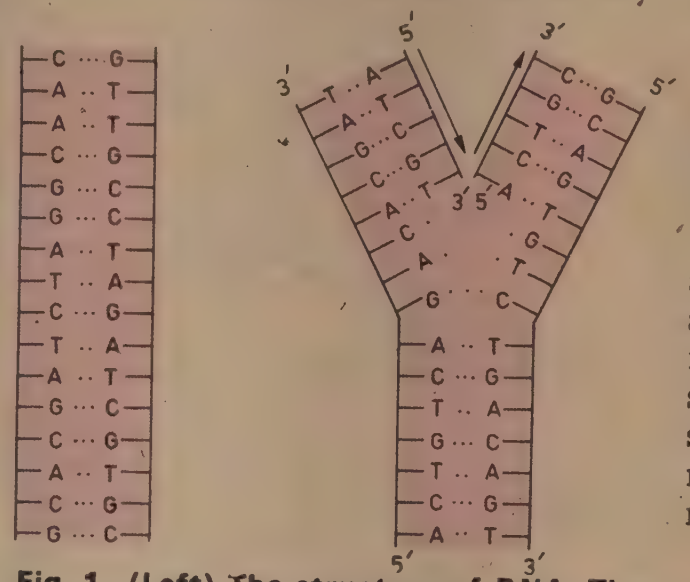


Fig. 1. (Left) The structure of DNA. The two vertical lines represent deoxyribose — phosphate diester chains. A, T, G and C are the bases. The dots between bases denote hydrogen bonds. (Right) Mode of DNA replication

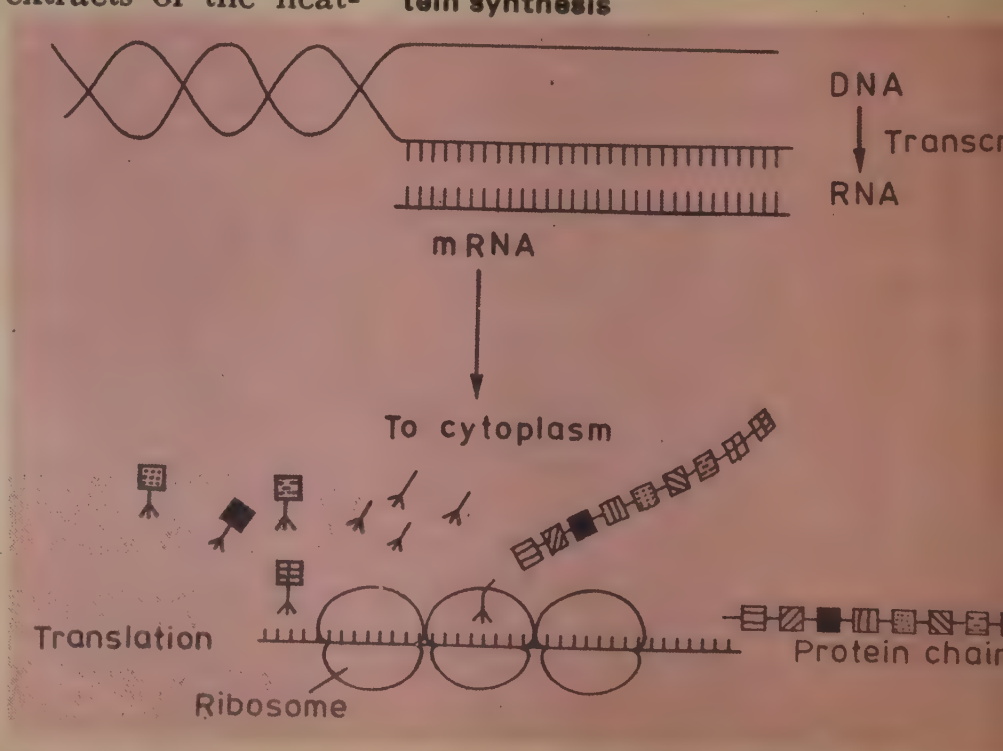
Griffith's transformation experiment, in fact, represents one of the two major methods in genetic engineering. Transformation is the process in which gene incorporation is achieved simply by incubating the recipient tissue with the desired segments of naked DNA. The mechanism by which foreign DNA molecules are taken up by the cell is not known satisfactorily, but recent researches amply document the phenomenon itself in many diverse kinds of cells. Transformation has been achieved not only in animals but also in plants. In plants, the tough cell wall has usually been thought to be a barrier to such uptake, but even this difficulty has been overcome by the use of naked protoplasts which are obtained with the help of enzymes such as pectinase and cellulase.

Isolation of pure and specific segments of DNA

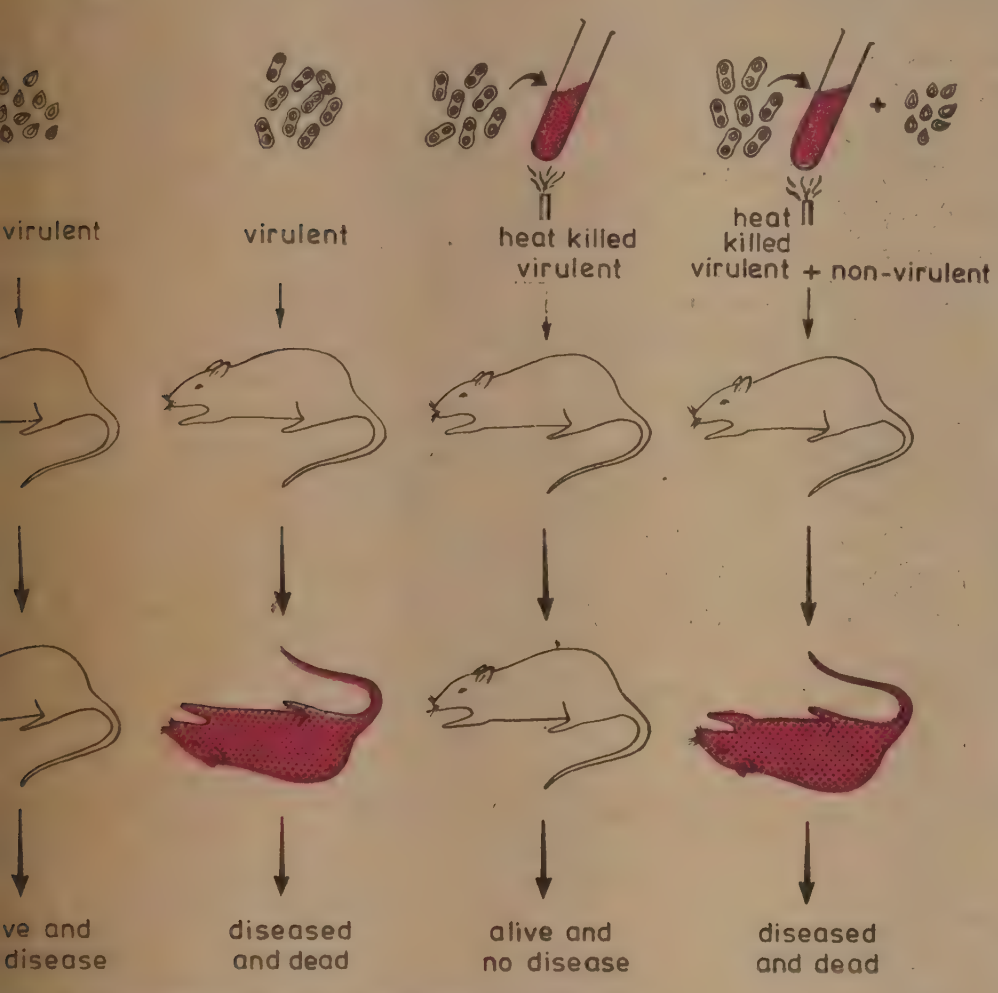
A more complex problem in genetic engineering, however, is the isolation of specific and well-defined lengths of DNA. Although, in the initial experiments, change in any character has been considered an achievement, for designed gene modification one must work with specific pieces of DNA. Happily, spectacular progress, which one could not dream of a few years ago, has now been made.

Jonathan Beckwith and his colleagues at the Harvard Medical School, USA, have developed an elegant technique for isolating any desired gene from bacteria. Its essence lies in picking up the same bacterial gene from two different phages in such a manner that in one the gene

Fig. 2. Schematic representation of protein synthesis



is picked the right way reading left to right, while in the other it is reversed. The phages have a very small genome and this step in itself constitutes a several-fold concentration of the required gene. They used the gene *lac* operon of the common intestinal bacterium *Escherichia coli* (Fig. 4). The gene codes for the enzyme β-galactosidase (lactase) enabling the bacteria to digest lactose. They separated the two strands (heavy and light) of the *lac* DNA of each of the phages and hybridised the heavy strand of one phage with the heavy strand of the other (Fig. 5).



ig. 3. Transformation experiment with *neumococcus*. Non-virulent, virulent, eat-killed virulent and heat-killed virulent plus non-virulent bacteria were njected into mice in different experiments (after Griffith, 1928)

In such a heteroduplex molecule, nly the region of the DNA containng the desired genes will hybridise ecause of the complementary seuence, the rest of the strands reaining unfused. This partly hybriised duplex molecule was next reated with the enzyme exonuclease, apable of digesting only the unaired ends of the molecule leaving he desired gene intact. The latter vas then purified and retrieved from he solution in which all these manilulations were being done.

In the higher organisms (eukarotes), because of the much higher mount of DNA per cell and the omplex organisation of the genes, he problem of isolation of a pure ene is much more complex. Neverheless, remarkable advances have een made even here. Unfortunately, or genetic engineers, most genes in he eukaryotes occur only singly. Therefore, it is not easy to apply the technique described above. However, there is a way out: one can employ purified reverse transcriptase, an enzyme which is akin to DNA polymerase (DNA polymerase is needed to translate the DNA gene into mRNA) with the difference that it makes DNA from RNA instead of making RNA from DNA (Fig. 6). If one can isolate a purified messenger RNA (such as haemoglobin messenger RNA), which is relatively rather easy, then all one has to do is make a DNA copy from it with the help of reverse transcriptase. Finally, instead of isolating ready-made genes or using reverse transcriptase to make a gene copy from natural mRNA, the techniques of organic chemistry can be used to synthesise the genes that one desires, just as Dr. Khorana and his colleagues have done recently (see SCIENCE TODAY, October 1976, p. 32).

To summarise, there are now many methods for obtaining defined segments of DNA and using them for transformation. All one has to do is provide the DNA pieces to growing cells in a suitable medium, and they will be taken up and replicated inside the host.

Transduction

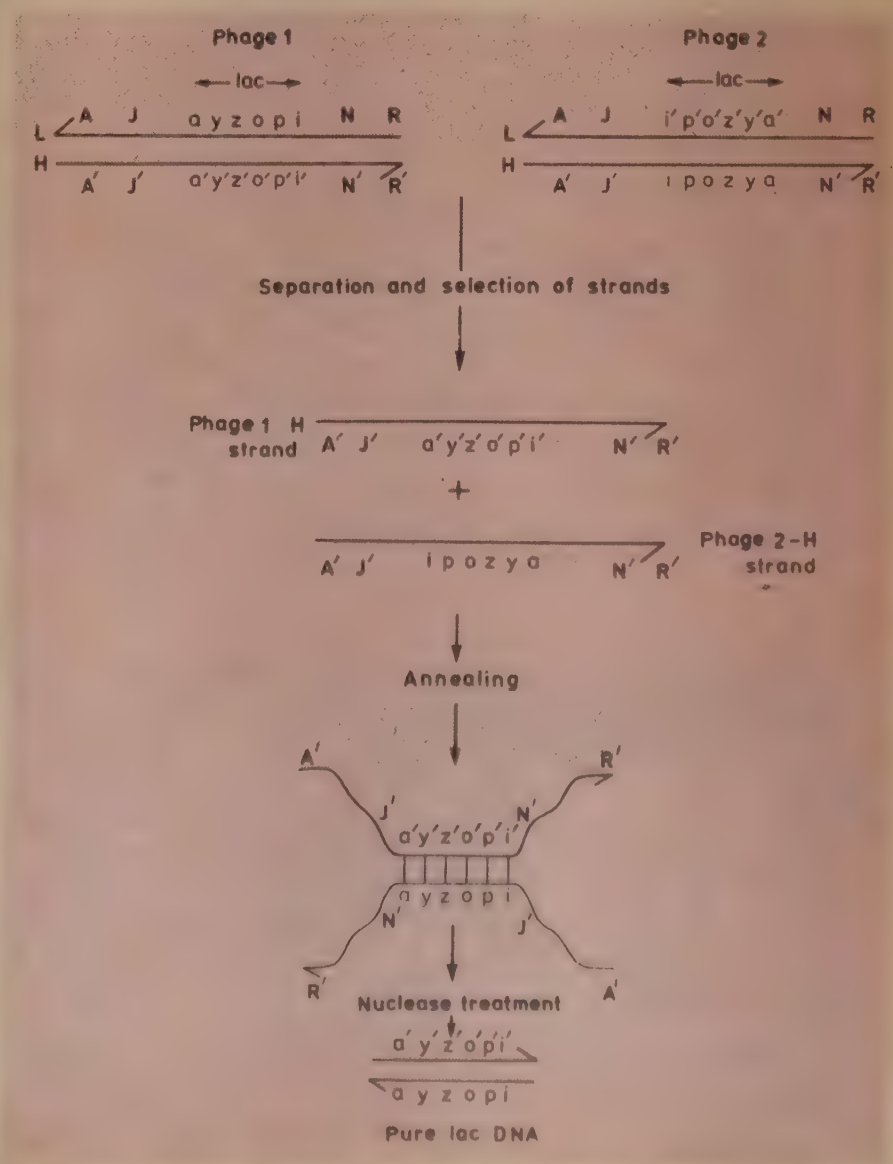
Another major technique genetic engineers make use of is transduction. This is a phenomenon, originally discovered in bacteria, wherein the DNA of an attacking bacterial virus (bacteriophage) gets integrated into the genome (the set of all different chromosomes found in the nucleus) of the host cell. The virus exists, so to say, as "prophage" in a dormant state in a benign fashion, replicating when the host

Fig. 4. Electron micrograph of pure *lac* duplex (Shapiro et al., *Nature 224*, 768, 1969)

genome replicates, until external conditions and other factors cause the prophage to educt and come out again from the bacterial genome. It then replicates rapidly and enters the destructive phase resulting in lysis and destruction of the bacterial cell and release of the viral progeny.

A point of special interest is that, during the process of eduction, the prophage often carries along with it

Fig. 5. Isolation of *lac* operon DNA of *Escherichia coli*. DNA molecules which constitute the genomes of two bacteriophages are shown. Each contains the *lac* operon, but the orientation of the *lac* region is opposite in the two genomes. A J N and R denote markers on the phage DNA. H denotes heavy strand and L denotes light strand. The 5′ end of each DNA strand is indicated by an arrow-head



contiguous segments of the host DNA. Thus, viruses can inadvertently serve as carriers of hereditary information from one kind of bacterial cell or even one bacterial species to another. A second point of interest to us is that, in the past decade, transduction by the invading viruses has also been found to occur in eukaryotic cells. Thus, SV40, a virus that attacks mammalian species, can not only transfer DNA from one host to another, but could also conceivably serve as an agent to carry even entirely new genes, if the same are covalently joined by an appropriate synthetic method to its DNA.

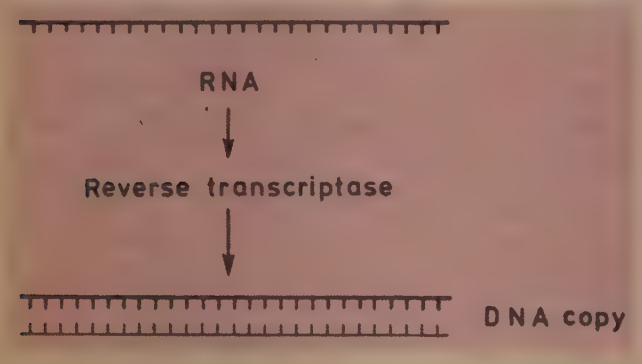


Fig. 6. Use of reverse transcriptase for the synthesis of an artificial gene

Genetic engineering through viruses (of course, these have to be of the non-virulent type) has several advantages over transformation with naked pieces of DNA. First, the viral DNA is protected from hydrolysis by a protein coat until almost the very last step. Second, the virus often carries its own information for the excision and joining of its DNA. Many scientists, therefore, consider transduction to be the method of choice for carrying out genetic engineering.

Newer techniques — plasmids and restriction endonucleases

Finally, some recent experiments have employed an altogether new technique involving the use of plasmids and two newly discovered groups of enzymes called restriction endonucleases and ligases. Plasmids represent extra segments of DNA in a closed circular form. They exist independently of the organism's own genes. They occur frequently in bacteria and carry additional information such as the antibiotic resistance factor. Not being part of the main genome, they can be isolated easily and, due to their small size, transferred from one kind of cell to another. Restriction endonucleases are highly specific enzymes (each specific enzyme chopping up DNA strands at particular sequences of bases) which can cleave a plasmid or DNA molecule in such a manner as to leave a sticky end at either side of the original duplex molecule. The free sticky ends serve as convenient points to align and join the new segments of DNA with the help of ligases or joining enzymes.

What the genetic engineer does is to introduce cuts in the recipient as well as the foreign DNA molecule by means of restriction endonucleases. If two such cleaved fragments are brought together and treated with ligase, they join despite their different origins, resulting in a chimera plasmid. This is then reintroduced in the original or a new strain of bacterium. These experiments are engineering experiments in the very literal sense, since splicing and joining of molecules are being carried out very much in the manner one cuts and joins tapes.

Using the above technique, several fascinating cases of genetic engineering have been reported recently. In one case, the ribosomal genes of toad (*Xenopus*) have been incorporated in the bacterium *E. coli*. In another case, the globin gene (for the protein part of haemoglobin) of rabbit has been introduced into the same bacterium (Fig. 7). All such strains of bacteria containing the chimera plasmids have been multiplying happily. Although, at the moment, it is not clear whether new proteins are being made, proof has already been provided that the bacteria do transcribe the foreign genes!

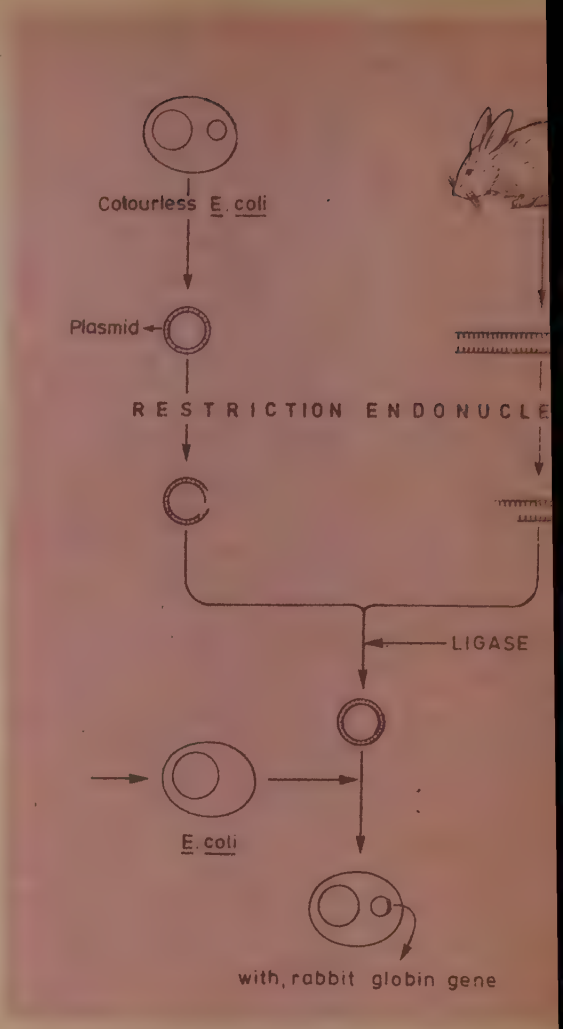


Fig. 7. Transfer of rabbit globin ge *E. coli* plasmid. Rabbit globin gene isolated by using restriction end clease. Simultaneously, the plasmid isolated from the *E. coli* and treated the same restriction endonuclease. lated globin gene was then joined t plasmid with the help of the enz ligase and reintroduced into the *E.* (after Rabbitts, 1976)

Experiments with plant tissue cultures

What about application of genetic enginee techniques in botany? For sev reasons, plant scientists seem to h a lead over their counterparts dea with the animal or human mate For one thing, notable advances h already been made in growing pl cells and tissues and manipulat them in several desired ways. E ploying aseptic culture technique is no problem at all to take individ cells or groups of cells from a part of several plants like *nicotia datura* and *petunia*, clone them, ra callus masses, and redifferentiate tire embryos and seedlings from the From a single cell, one can ha virtually infinite numbers of identi copies of plants or embryos, havi the full potency of flowering a fruiting. It is clear that in such system, if the genetic modificati can be carried out in the init single cell, all its progeny will also stably altered. Further, in pla systems, one can also have t haploid (containing only one of chromosomes) instead of the usu diploid tissues for experimentatio The use of haploid recipient ce (the technique was initially dev loped at the senior author's labor

tory) obviates the problem of segregation and of further selection which would be needed if diploid tissues were used, since the chance of introducing the same foreign gene identically in both sets of chromosomes when haploid cells are used is very small.

Further, the importance of genetic engineering work in plants has the added attraction that, whereas in the world of humans or animals, genetic engineering can at best benefit only a very small percentage of the population, used in plants it can produce results of value to the whole of mankind. For example, if the nitrogen-fixing genes could be introduced from bacteria such as *rhizobium* and *azotobacter* into higher plants, the problem of protein malnutrition could be solved (see SCIENCE TODAY, December 1975, p. 15).

Fig. 8 illustrates one of the first instances of genetic engineering techniques applied in plants. This experiment is on the lines of the transduction method. The recipient cells are haploid callus of *Arabidopsis* and *Lycopersicon* (obtained, through the anther culture technique; see SCIENCE TODAY, June 1976, p. 13) whereas the donor is a special lambda phage (a bacterial virus) carrying the *lac* gene. The *lac* gene synthesises the enzyme β-galactosidase (lactase) and confers upon the cell the ability to grow in a lactose medium. Similar experiments have been done by Smith's group in the UK on sycamore cells. Our own experiments on *datura* are as yet preliminary, but indications are that here, too, modification occurs.

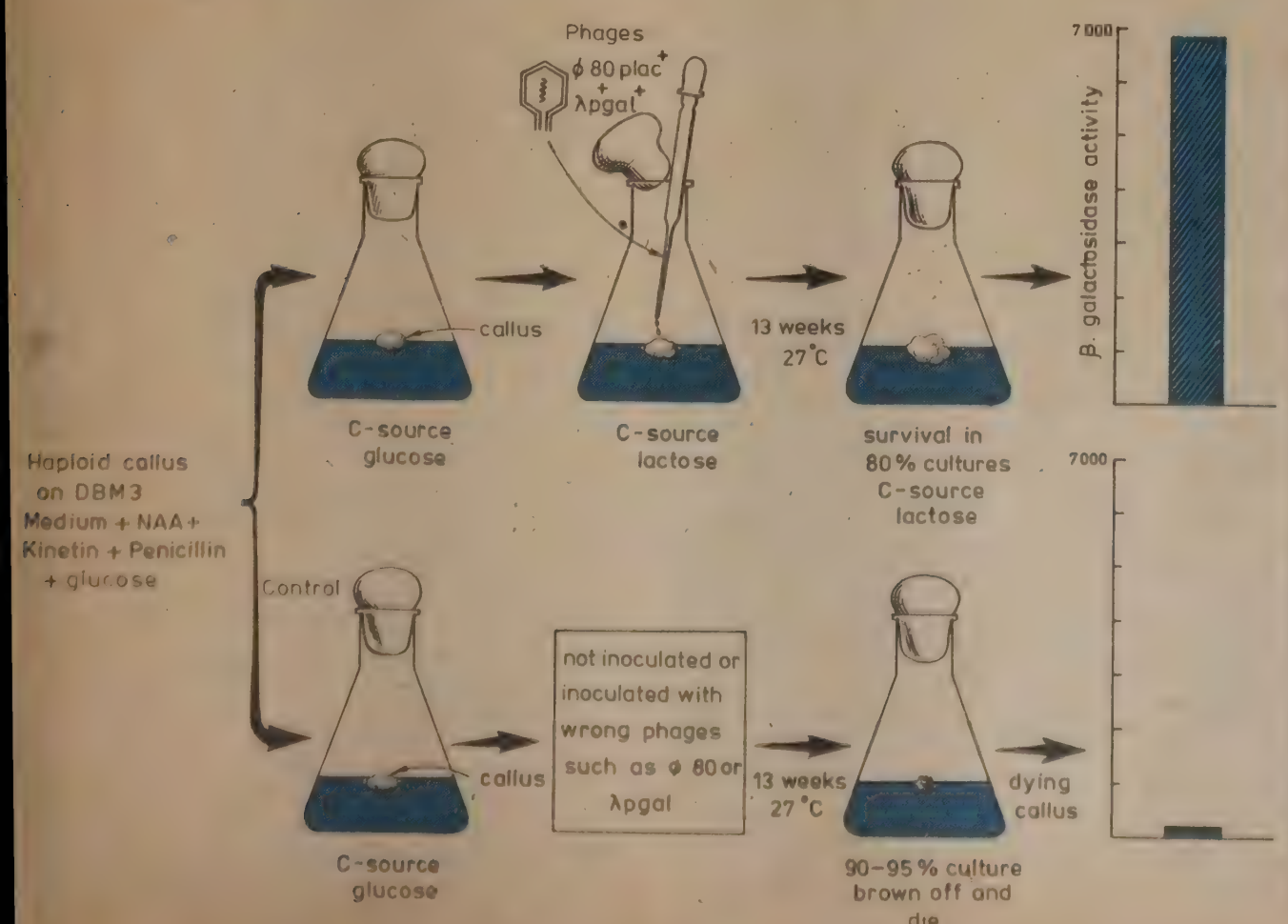
In the above experiments, the *lac* operon has been deliberately chosen as a donor since geneticists know this system in minute detail and even pure *lac* DNA has been isolated. While these genes are, perhaps, of no immediate interest to the agriculturists (and reports are that the recipient cells lose these genes after some weeks of sub-culture), it is remarkable that they can function even for a few weeks in an absolutely foreign cell. What remains to be done is to investigate in detail the fate of the virus inside the host cells, that is, whether its DNA is integrated into the main genome or it remains separate as a plasmid.

The practical genetic engineering experiments, however, have so far fallen far short of the really sensational. In fact, till now no really useful genes have been transferred. However, the experiments have paved the way for a better understanding of the technology of genetic engineering.

There is a growing realisation that genetic engineering is a double-edged sword and is liable to misuse. Even if one rules out deliberate vicious designs to manipulate human, animal or plant genes, there can be inadvertent laboratory accidents. One such case has already come to light. A virus called *Shope papilloma*, upon infection, can bring about a lowering of the level of arginine by increased production of the enzyme arginase. It was found a few years ago that, in the blood of researchers working with this virus, there was a definite decrease in the arginine level, although happily not below the critical level.

In fact, there is a genuine fear among many scientists that if work on genetic engineering, as practised at present, continues unabated, the chances of releasing new and dangerous bacteria and viruses will be so great as to nullify any advantages that the current research might bestow upon humanity. The pros and cons were thrashed out recently at a conference of geneticists held in Asilomar in USA and a set of guidelines have been released to scientists. But despite cries of caution, work on genetic engineering is accelerating as scientists foresee more benefits than harm.

Fig. 8. Transgenosis experiment with haploid callus of tomato. Callus inoculated with λ *lac* phage shows higher β-galactosidase activity but the callus without phage inoculation or inoculated with wrong phage shows less β-galactosidase activity (after Gresshoff, Doy and Rolfe, 1973)



S. C. Maheshwari, 43, is Professor and head of the Department of Botany, Delhi University. After his PhD from Delhi University (1958) he did post-doctoral research at the Yale University, USA, as a Smith-Mundt-Fulbright Fellow (1959–60), and then at the California Institute of Technology, Pasadena, USA, (1960–61), which he visited again (1972–74) as a Homi Bhabha Fellow. He was awarded the S. S. Bhatnagar Award in 1975.

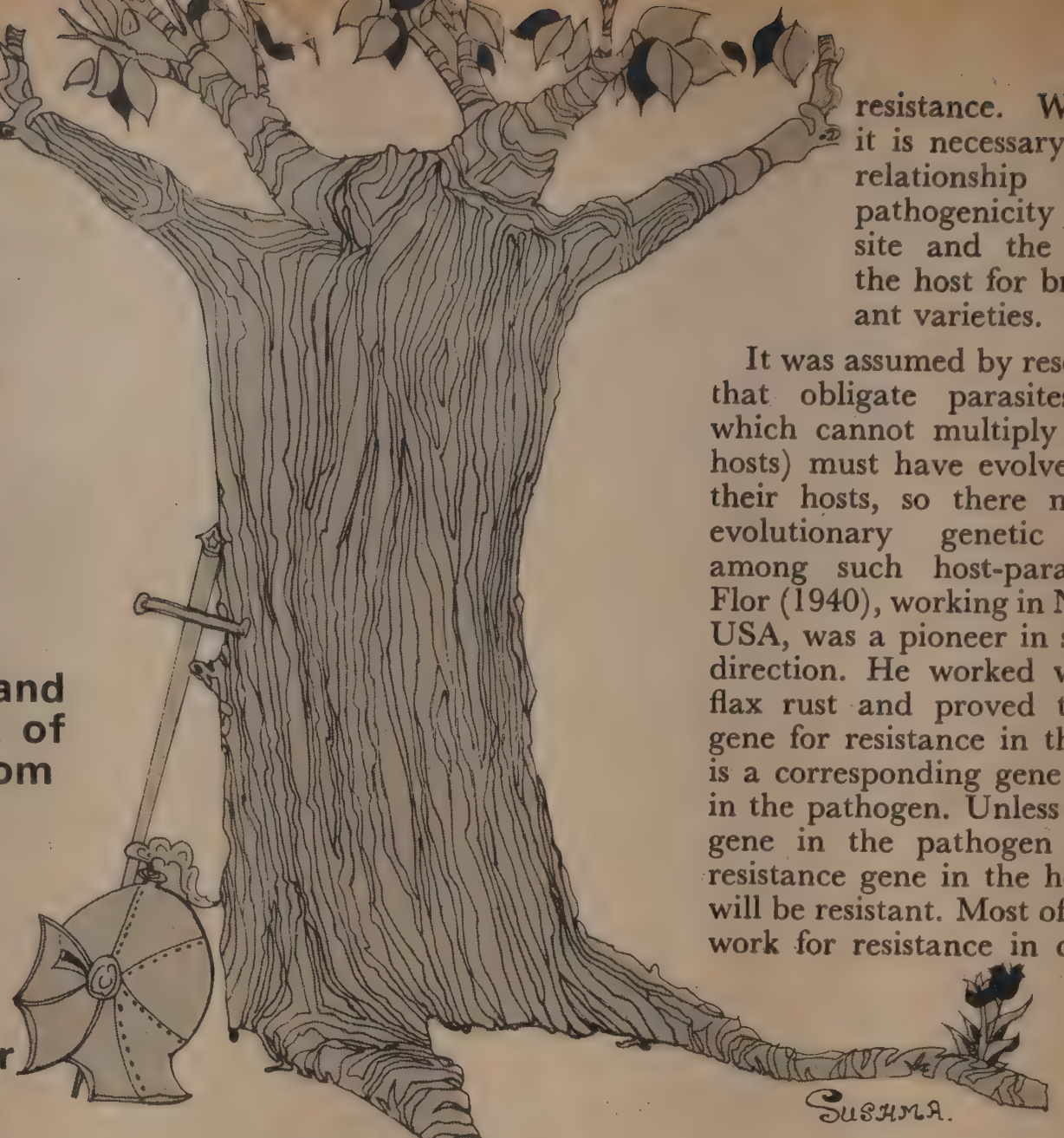
Kusum Malhotra is a Junior Research Fellow of the CSIR, working with Prof. Maheshwari.

(Below) The authors in their laboratory.

HOW PLANTS FIGHT DISEASE

JAGDISH KUMAR
P. S. PHUL

An economical, safe and non-polluting method of saving crop plants from damaging diseases would be to breed resistance into them by making use of our knowledge about their inherent resistance to particular pathogens



About 10 per cent of our crop production is estimated to be lost to diseases which in epidemic form may totally damage the harvest or make it unfit for human consumption. The Irish potato famine of 1845 (caused by late blight), the coffee rust epidemic in Sri Lanka in the last century, the Bengal famine of 1942 (brown leaf spot of rice) and the more recent leaf rust damage to the wheat (Kalyan Sona) crop in India in 1971–72 and 1972–73 are some examples. However, not all plants are susceptible to a particular disease-causing pathogen; most of them have a built-in resistance. It is mainly due to interference by man that varieties released for general cultivation (with narrow genetic base for resistance) are vulnerable to diseases, which under favourable conditions strike in epidemic form.

For instance, the Irish potato famine almost certainly was due to the fact that the Irish grew mainly the susceptible variety "Lumper"; thus the potatoes grown were genetically identical and the disease could build up rapidly. A more recent example is the Southern corn leaf blight in the USA in 1970. In that year, nearly every farmer in that region grew corn which carried the Texas cytoplasm (T cms), and this was the only corn infected.

Hence, to avert such disasters, it is important that we study the pathogens that cause plant diseases, understand how plants resist the disease and devise means of reducing the damage caused to the crops.

Disease can be eliminated or minimised through (*i*) prophylactic (preventive) measures where the chances of contact between the host and the pathogen are reduced; (*ii*) therapeutic measures where physical means are used to contain the multiplication of the pathogen; and (*iii*) exploitation of the resistance, where the built-in structures or metabolites of the host are manipulated genetically to prevent the entry of the pathogen into the host tissue, or its multiplication. Of these, the utilisation of the host resistance is a stable way and, in fact, provides an easy, cheap, safe and, in many cases, the only feasible method of reducing disease losses.

It was De Bary who first proved that fungi caused plant diseases. Later, it was shown that not all plants in a species were susceptible to a particular disease and that different diseases are caused by different pathogens. With the rediscovery of Mendel's laws in 1900, genetic studies of disease resistance were taken up. Prof. Biffen (1905) of Cambridge, England, proved that the resistance was governed by genes. Barrus working with beans and bean-anthracnose and Stakman with wheat and wheat-stem rust observed that the pathogens vary in their capacity to cause disease just as the host plants vary in their resistance. Which mean it is necessary to study th relationship between th pathogenicity of the para site and the resistance the host for breeding resis ant varieties.

It was assumed by research worke that obligate parasites (pathoge which cannot multiply outside thei hosts) must have evolved along wit their hosts, so there must exist a evolutionary genetic relationshi among such host-parasite system Flor (1940), working in North Dakot USA, was a pioneer in studies in th direction. He worked with flax an flax rust and proved that for eac gene for resistance in the host, ther is a corresponding gene for virulenc in the pathogen. Unless the virulenc gene in the pathogen matches th resistance gene in the host, the plan will be resistant. Most of our breedin work for resistance in crop plants based on exploitation of this funda mental principle. This type of com plete resistance governed by the majo genes is called 'vertical resistance' Another type of resistance which i polygenic (having multiple deter minants) and imparts partial protec tion is called 'horizontal resistance'

For the breeding of resistant crops one can incorporate in the plant major resistance genes which do no have matching virulence genes in the prevalent races of pathogens and the new varieties then become resistant to the existing ones. However, it i known from past experience that wide cultivation of such varieties would soon result in rapid selective multiplication of newer virulent forms o pathogen race(s) and the resistant varieties would succumb to the parasite. In this respect, varieties possessing horizontal resistance are more suitable for breeding since the pathogen is not subjected to differential selection pressure. However, incorporation of such resistance is difficult and laborious. More study is needed to understand and utilise this. Judicious management of vertical resistance genes, over space and time and in multilineal and multigenic cultivars may also help in reducing differential selection pressure on pathogens.

One of the most fascinating aspects of the host-parasite tug-of-war is the study of how the resistant genes act on the pathogens. The simplest mechanism will be that

the host surface is inhospitable to the spores of the parasite. The surface may include a thick wall of hair, thick waxy cuticle, and thick-walled sclerenchymatous (composed mainly of sclereids — liquefied plant cells) tissue, making the entry of the parasite into the host body difficult. One or more of such mechanisms may be found in the resistant plants (susceptible hosts lack these). Such examples are found in wheat, cotton and many other crop plants. And these may be normal features of the host, even when it is not attacked by the pathogens.

Perhaps, a more important aspect is the structural and metabolic changes that occur in the host when it is attacked by a parasite. This includes formation of cork layers against common scab as in potato, formation of abscission layers against *xanthomonas* as in peach, and deposition of gum as in rice blast disease. Other mechanisms are swelling of cell walls of the invaded cells, as in cucumber against scab, and change in the texture of the cytoplasm of cells of certain plants.

Many plants have certain specific metabolites produced either before or after they come in contact with the parasite. These interfere with the normal growth and development of the parasite. Resistant varieties of tomato, sugarbeet and gram produce fungitoxic substances on their leaves so that the spores cannot germinate. In onion, red-scale varieties are resistant to smudge as they have protocatechuic acid and catechol which are toxic to the spores. Also, certain substances produced in the normal metabolic pathways of many resistant plants are toxic to their parasites. Potato resistant to potato scab has more chlorogenic acid than susceptible varieties. Resistant varieties of many crop plants have more phenols and alkaloids in their cells. Differences in the quantity and quality of amino acids, sugars and minerals are found in resistant and susceptible cultivars. Cotton varieties having none or low content of an alkaloid, gossypol, are more vulnerable to their pathogens than those having high gossypol content.

Some studies have shown that production of certain fungitoxic substances is considerably increased in resistant plants when they are attacked by pathogens. These include aglucones and peroxidases in wheat and maize. Production of phytoalexins in peas, beans, sweet potato, soyabean, carrot and in many other crops has been reported.

Some plants are extra-sensitive to the attack of certain pathogens. As soon as the pathogen establishes itself slightly in the host, the tissue immediately surrounding the pathogen dies, cutting off its nutrition, and the pathogen is not able to multiply any further. This behaviour of plants is called hypersensitive reaction and occurs in a variety of crops.

The antigen-antibody interaction so commonly present in animals and their pathogens has also been reported in plants. Serological studies in plants have shown that rust-resistant varieties of flax do not have common antigens with the flax rust and, therefore, are capable of producing antibodies against foreign antigens. Similar reports have also been published for maize. However, it is doubtful if true antigen-antibody relationships, as in animals, occur in the host-parasite system of plants.

If the presence or absence of the defensive structures and chemical metabolites in the resistant and susceptible plants can be attributed to specific genes, breeding for disease resistance would become a simple enterprise. In corn and northern corn-blight, and soyabean and soyabean root and stem rot, such relationships have been proved to some extent. However, in most cases, specific changes cannot be related to specific genes and, therefore, transfer of these mechanisms from resistant to susceptible varieties has not been accomplished.

Single gene resistant lines are becoming available in many crop plants, for example, in wheat against stem, leaf and stripe rusts, in oats against crown and stem rusts, in potato against late blight and in a host of other crops plants. Study of the differences in their morphological and biochemical features may be fruitful in analysing the real mechanism of resistance in crop plants. This will also throw some light on the mechanism of gene action in higher plants. Once this is understood, we may be able to fight the battle against pathogens from a stronger platform.

Dr. Jagdish Kumar (30) took his doctorate in plant breeding from Canada, and is now an Assistant Professor at the Punjab Agricultural University, Ludhiana. His main research area is "breeding for disease resistance".

Dr. Pritpal Singh Phul (39) is an Associate Professor at the same University from where he obtained his PhD in 1967. He is joint secretary of the Crop Improvement Society of India since its inception in 1974.

IN LIGHTER MOMENTS

DESPITE the rivalry and hostility between England and France, Napoleon not only recognised the benefits of vaccination and allowed all facilities for it in his empire, but paid rich tributes to its discoverer, Jenner. Once, when Jenner sent a request to Napoleon for the release of a friend who had been arrested in Paris, the latter is said to have ordered his immediate release: "Jenner, ah, / we can refuse nothing to that man."

* * *

IT was on 8 November 1847 that James Simpson first used chloroform. It was an obstetric case and the patient was a physician's wife. Neither the patient nor her husband was told that the new anaesthetic agent was being used for the relief of her pain: a pocket handkerchief was simply moistened with chloroform and put over her face "inadvertently". When the baby grew up to be a seventeen-year-old girl and her photograph was taken, Simpson took a copy of that photograph, captioned it "Saint Anaesthesia" and kept it on his study table.

* * *

THOUGH the inventor of the negative/positive process of photography, William Henry Fox Talbot, had got his process patented all right, he laid no conditions for its use by amateurs. A notice to this effect was given on the packets of his iodised paper: "This paper is prepared for the convenience of amateurs who engage to use the same *bona fide* for the purposes of amusement only. Persons wishing to make commercial or professional use of the Art can take out a Licence from the Patentee".

* * *

THE hunch-backed German-born American Charles Proteus Steinmetz (1865-1923), discoverer of the law of hysteresis (a phenomenon exhibited by certain solids when subjected to stress and released) and inventor of lightning arrestors to protect high-power transmission lines, was also a socialist and an active crusader for his ideology. During his student days at the University of Breslau, he used to write letters in invisible ink to his comrades in jail. He also edited the socialist weekly *The People's Voice*, which carried a very challenging but meaningless motto on the first page: "We don't know what the Government wants, but we are against it."

* * *

WHILE making some experiment in his wife's kitchen, the mid-nineteenth century German-Swiss chemist Christian Frederick Schonbein accidentally spilled some nitric acid which he cleaned with a cotton apron lying there. Later, when he tried to dry the wet apron over the kitchen stove, it vanished "with a smokeless bang". He had discovered cellulose nitrate or gun-cotton.

S. N. MUNSHI

INSTRUMENTATION

Improving hearing aids

The hearing aid has helped to normalise the lives of those handicapped by deafness. It essentially amplifies the sound signal to compensate for the loss in the impaired ear. The complexity of the incoming signals, however, demands a proper design of the amplifier.

Deafness is generally of two types: (1) conduction deafness arising out of attenuation of signal at the middle ear, and (2) the more severe sensorineural deafness, which signifies lack of sensitivity, caused by damage to the cochlea. The former defect can be ameliorated by hearing aids and surgical treatments. But the latter presents a number of problems inclusive of (*i*) loss of sensitivity to high frequencies, (*ii*) tinnitus-whistling sound, and (*iii*) recruitment—reduction of dynamic range for intensity. Linear amplification, in which the output is a fixed multiple of the input sound signal, can compensate signal attenuation of conduction deafness. But, in sensorineural deafness, this would amplify the peak sound intensity above acceptable limits, producing distortion, non-intelligibility of speech and often pain and further damage to the ear. Fortunately, energy peaks are not important as carriers of speech information and it was postulated that information could be transmitted through the hearing aid without overloading by suitable peak clipping of the signal. But mere amplitude clipping was found to produce unpleasantly distorted sounds and tones with reduced intelligibility.

R. L. Gregory and A. E. Drysdale of the Medical Research Council's Brain and Perception Laboratory, Department of Anatomy, University of Bristol, UK, have found a modified method, called High Frequency Carrier Clipping (HFCC) to be more effective. They have reported in *Nature* (**264,** 748, 23/30 December 1976) that the undesirable speech harmonics (the multiple frequency components of the fundamental frequency) and the cross-modulation (the modulation of harmonics) could be avoided by amplitude modulation of a high-frequency carrier with the speech, and then clipping the carrier. The harmonics and cross-modulation products, in this situation, get widely separated from the speech band and can be filtered out. The result is limitation of the audio peaks without appreciable intermodulation distortion.

The authors have tested the method on children and adults suffering from sensorineural loss. They compared its effectiveness with the other two types of speech processing — linear amplification and audio-frequency peak clipping. Speech from pre-recorded test tapes was used for processing by each of the three methods. The audio-frequency band was restricted to 400 Hz-2·5 kHz and 16 dB (the normal dynamic range of speech is about 60 dB with a mean of about 40 dB) of clipping was used both for audio-frequency peak clipping and HFCC. It means the signal was amplified by 16 dB and then reduced to the original level by clipping. Each test lasted about one hour under optimised condition and included about 350 individual words, or 175 test sentences. The experimenters observed that most subjects showed an improvement of word recognition with HFCC ranging from + 145 per cent to — 35 per cent. Peak clipping was less effective than HFCC.

The speech amplitude limited in this manner was louder and sounded almost normal, possessing a considerable increase in intelligibility. According to the authors, the main advantage of HFCC is its ability to amplify the information-bearing features of the speech wave while limiting the peak energies to a safe value, and thus protecting the cochlea from unnecessary damage.

For a practical hearing aid suitable for sensorineural deafness, the entire dynamic range of sounds reaching it should be considered, and the output must remain tolerable even under high intensities; the dynamic range of speech should, in fact, reduce proportionately to the rise in pure tone threshold. The upper mean limit considered safe in industry is 90-100 dB and distortion of speech becomes significant at peak energies of about 120 dB. The UK scientists feel that with advances in electronic circuits, practical hearing aids using their method could be developed for regular use.

A. V. SAPRE

[Dr. Sapre is with the Regional Instrumentation Centre of Bombay University.]

MEDICINE

Prostaglandins and asthma

Prostaglandins, the wonder chemicals, continue to be a subject of intense investigation for their multifarious effects. It is now established that the lungs are one among the many organs that generate, release and destroy prostaglandins (PGs). PGE_1 and PGE_2 have been found to be bronchodilators — they relax the smooth muscle of bronchi and pulmonary blood vessels in many species — whereas $PGF_2\alpha$ has been found to be a bronchoconstrictor and, hence, has been proposed as a factor in inducing asthma. Cough and airway irritation have been reported in clinical trials of PGE_1 and PGE_2 as bronchodilators in the treatment of asthma.

Drs. H. M. Coleridge, J. C. G. Coleridge, K. H. Ginzel, D. C. Baker, R. B. Banzett and M. A. Morrison of the Cardiovascular Research Institute, University of California, San Francisco, USA, have recently studied the stimulation by prostaglandins of the afferent nerve endings in the lungs of anaesthetised dogs. They have, in fact, recorded the induced impulse activity in pulmonary stretch (irritant) receptors and vagal C-fibre endings and thrown further light on the role of prostaglandins in asthma. The details are reported in *Nature* (**264,** 451, 2 December 1976).

The majority of "irritant" receptors in the lung are believed to be in the larger airways supplied by the bronchial circulation, whereas vagal C-fibre endings are located in structures supplied by both the pulmonary and the bronchial circulation. During the experiments, the scientists measured not only the impulse activity of fine strands (containing one or two active fibres) from the nerves but also the systemic and pulmonary arterial blood pressure and the peak tracheal pressure. The prostaglandins were injected into the right and left atrium or administered as aerosols.

They found that an average dose of 4 μg per kg of $PGF_2\alpha$ injected into the right atrium significantly increased the "irritant" receptor activity; it also increased the peak tracheal pressure. Similar results were obtained when $PGF_2\alpha$ was administered as an aerosol. This prostaglandin was also found to stimulate the afferent C-fibres, but to a lesser extent. The administration of an aerosol of isoproterenol or PGE_2, which has been shown to reduce the bronchoconstrictor effect of $PGF_2\alpha$ significantly, reduced the effect of $PGF_2\alpha$ on both receptor activity and tracheal pressure. Injection of $PGF_2\alpha$

to the left atrium, however, did not ave any significant stimulatory effect n the "irritant" receptors.

Both PGE_1 and PGE_2, known to ighly irritate the airway passages, ere found to have only minor ffects on "irritant" receptors. PGE_2 as, however, found to be a powerful imulant of lung C-fibre endings. ut the effect, contrary to previous bservations, was extremely prolonged average duration 6·5 minutes). The alifornia scientists cannot offer any xplanation for the observed pro- nged effects. In the same dose ange, PGE_1 had similar but less rolonged effects on C-fibre endings.

Dr. Coleridge and his colleagues tate that their results indicate that $PGF_2\alpha$ stimulates 'irritant' receptors egularly only when it has access to the pulmonary circulation, from which site it produces its maximal bronchoconstrictor effects". They hypothesise that the stimulation of the "irritant" receptors may not be primarily due to the effects of $PGF_2\alpha$ on the nerve ending, but secondary to changes in the lung mechanics. However, the possibility that $PGF_2\alpha$ also stimulates "irritant" receptors directly cannot be ruled out from their results. They conclude that, if $PGF_2\alpha$ has indeed a positive role in asthma, then their results have considerable patho-physiological significance. It is also conceivable from the results that C-fibres rather than "irritant" receptors are responsible for the PG-induced cough in the treatment of asthma.

K. A. NEELAKANTAN

PLANT BREEDING

Protein-rich grains

Can protein malnutrition, if at all it exists, be solved by increasing he protein content of crop plants? On the surface, the method looks romising, but experience indicates hat new plant stocks with increased rotein (or altered amino acid com- osition) repeatedly have decreased ields. In fact, many experiments ndicate that the grain protein con- ent correlates inversely with the ield in cereals. Drs. C. R. Bhatia nd R. Rabson of the joint FAO/ AEA Division, International Atomic nergy Agency, Vienna, have examin- d the energetics of grain production nd reported in *Science* (**194,** 1418, 24 December 1976) the reasons for the ower yield. (Dr. Bhatia is at present ith the Biology and Agriculture ivision, BARC, Bombay.) Accord- ng to them, the plant has to invest nore than the normal amounts of nergy for production of protein- ich grains.

Plants derive their energy from hotosynthesis and this energy is sed up mostly in the synthesis of arbohydrates, the major grain com- onent. It has been found that pro- ein synthesis in plants requires twice s much energy expenditure as the ynthesis of carbohydrates. For ex- mple, under aerobic conditions, 1 gm f glucose produces 0·83 g of carbo- ydrates, or, alternatively, 0·40 g of roteins (assuming nitrate to be the itrogen source) or 0·33 g of lipids. lence, plants that invest their energy high-protein grains have less energy vailable for synthesising more grains, esulting in decreased yields.

The IAEA scientists argue with evi- ence that increasing the protein ontent of the grain without reducing the yield may thus require far-reaching changes in the plant metabolism. For example, this would involve a higher rate of photosynthesis, more leaf area, a longer period of photosynthetic activity or mobilisation of the energy reserves of the plant into the grain. Also, an increment in nitrogen input is needed to produce the additional grain protein. They have calculated that each one per cent increase in grain protein would require an additional six to 11 per cent nitrogen, which can come either by direct uptake from the soil or by greater mobilisation of the nitrogen present in leaves and other plant parts.

They show that their arguments would apply equally well even to an increase in particular amino acid components of the protein in the grain. An increased lysine concentration would mean a higher nitrogen utilisation and greater nutritional efficiency. By calculations they point out that the energy requirements of protein synthesis in both maize and barley are slightly higher in the high-lysine stocks than in normal stocks.

They conclude from their results that cultivars with increased protein concentration would not only have a lower yield, but the nitrogen fertiliser requirements would also be higher. They state that the rice cultivar IR-8 with 8 per cent grain protein may yield about 6,000 kg/ha under optimal growth conditions. If it were to be replaced by a cultivar with 10 per cent protein in grain, but with the same yield, the nitrogen requirement would increase by 24 per cent. They suggest that breeding experiments for protein-rich plants be conducted at higher soil nitrogen levels than considered optimal for the current commercially grown cultivars. K. A. N.

ENTOMOLOGY

Diet-pheromone theory challenged

The theory that female insects use steroid hormones, called pheromones, as sex-attractants is now rather well established. But what is in dispute is the origin of these chemicals. Till two years ago, it was thought that pheromones are manufactured by the insect's metabolism and released during the mating call. But a group of entomologists led by Lawrence B. Hendry of the Pennsylvania State University had almost thrown a bombshell at this well accepted theory. By studying the oak leaf-roller moth, a pest that seriously damages forests in the north-eastern United States, they concluded that pheromones are dietary in origin. Their evidence was that the same chemicals were present both in plants and in insect pheromones; males were attracted by a variety of these chemicals and the chemical nature of the pheromones in the female moth varied with diet.

Drs. D. M. Hindelang and J. K. Wichmann, Department of Chemistry, Pennsylvania State University, USA, two former co-authors of Prof. Hendry in the original research paper which first proposed the diet-pheromone theory, have now retracted their previous stand. By a more thorough analysis of the insect pheromones and plant chemicals using micro-ozonolysis and computerised gas chromatography-mass spectrometry, they conclude that it is no more appropriate to hypothesise a direct association between plant chemistry and insect sex pheromones. In their experiments reported in *Science* (**195,** 86, 7 January 1977), they found that the chemical composition of the female oak leaf-roller moth pheromone is a specific blend of an approximate 70 to 30 ratio of E and Z–11 tetradecenyl acetates. This result was consistent with that reported recently by J. R. Miller and his colleagues in *Science* (**192,** 140, 1976). What is more, in tests of plants they found no pheromone chemical in highly purified oak leaf, apple leaf or corn extracts. They state, "if any tetradecenyl acetates were present in these oak leaf extracts they would be present on the order of one to ten parts per trillion or less". The new results reflect negatively on their previous work and on the hypothesis that plant components might govern insect chemical communication systems.

K. A. N.

The Scientific revolution in Search of a blueprint

Why is it, I have often wondered, that almost all major scientific discoveries and technological feats reported today are those made abroad? India has as many qualified scientists and engineers as has Great Britain. In fact, in numbers, they come next only to those in the United States or the USSR. Then, how is it that an Indian scientist working in India rarely makes important scientific news?

Yet, it was not so barely four or five decades back. With much fewer scientists and a not very helpful foreign regime, India still managed to throw up quite a few giants then. Like Ramanujan and Jagdish Chandra Bose and C. V. Raman, Meghnad Saha and Satyendranath Bose, K. S. Krishnan and Homi Bhabha. It also produced a fair number of eminent technologists and engineers who made significant contributions in their own fields.

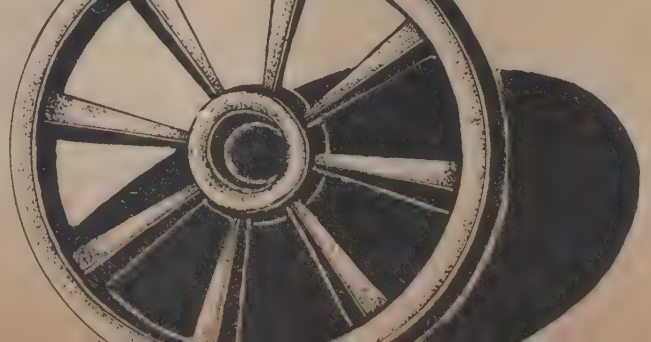
It is not that lately, specially since Independence, political support to science and technology in India has been lacking. Far from it. Years before Independence, Jawaharlal Nehru had seen in science a great promise for an underdeveloped country like India. And so, when he came to power, he set out to pursue this vision with some passion. He had a whole range of laboratories set up throughout the country. He appointed eminent scientists to advise on developmental policy. He had the Indian parliament adopt a Science Policy Resolution — perhaps the first document in the world to declare formally a state's commitment to science.

This support to science and scientists continued unabated during the premiership of Indira Gandhi. Research and developmental budgets showed phenomenal rise from year to year. Even middle-level scientists and technologists were brought in for consultations. And, later, she inducted quite a few of them into government as the all-powerful secretaries to various departments.

Why, then, have we not been able to reap the full benefits of these investments? Is there something wrong with the way we do science here, or with our social and political system, which is smothering the creativity of our scientific men? Perhaps, there is. How else would one explain the fact that, although we were among the earliest nations in the world to start work on nuclear energy, and can boast of possessing a fine band of talented scientists, we have yet to design entirely on our own and build even one nuclear power station?

Our oil exploration programme started with a bang at the turn of the fifties, and we soon discovered what a bright, promising group of oil scientists and technologists we had amongst us. But, after a few initial impressive successes, we allowed our programme, and along with it the enthusiastic band of scientists, to languish, until we were hit by a terrible oil crisis.

India is primarily an agricultural country, with a fairly long tradition of agricultural research. We also have some of the first-rate men in agricultural sciences. And yet, it was Mexico which had to give us the know-how of the high-yielding variet of wheat, and Manila, the first high yielding strain of rice.



And, although we started muc earlier, and had an almost head start over other underdeveloped coun tries, we have not even been able t keep abreast with the scientific an technological developments of a neigh bouring country, China. Why?

Maybe, if we looked into wha indeed modern science represents how it originated and what kind of supportive culture it needs to prosper we may stumble upon some clues.

Modern science, es sentially, represents a new way o thinking, looking at and doing things It challenges self-evident truths, an seeks, through research, systematised positive knowledge. It tries not only to explain some part of the whole but to see the entire pattern, and determine how the parts hang to gether. In its most fundamental sense it has been stated, it is just a new approach to solving problems — an approach based on logic and tempered by experience.

Whether you are seeking to solve the mysteries of an atomic nucleus, or proposing to land a man on the Moon, the steps you take are broadly the same: you determine what is your problem; you collect facts for or against, through observation and experience; you form a hypothesis or scientific guess after discarding what you think is irrelevant; and then you test your hypothesis by carefully controlled, repeatable experiments.

But such an approach took a couple of centuries to evolve. It needed certain conditions to prosper and they became available in western Europe two-three centuries ago.

Western Europe was then experiencing a rather expansive and buoyant phase. Daring voyages to distant lands and stories about civilisations and people of different races, different mores and different social and political systems were having an electrifying effect on a population lulled by medieval immobility and mental torpor. It was an age characterised by at least three significant developments.

One was the feeling of elation and release these discoveries engendered. They led to a growing attitude which, in the face of new knowledge and new evidence, now not only was ready to discard the previously held ideas and beliefs, but also let the liberated mind explore, reason and arrive at conclusions on its own.

The second was the pressing demands the expanding commerce and frequent wars of conquest made on the

roblem-solving ability of innovative en. They were called upon to make ntinuous improvements in the exist- g modes of manufacture and trans- rtation systems.

And the third was the coming gether of, and continuous inter- ction between, this new breed of in- llectuals and enterprising artisans to lve the practical problems of the day.

This age was also characterised by ne mushrooming of scores of me- hanics' institutes and philosophical cieties whose membership included radesmen, scientists and businessmen. hey organised libraries, arranged ublic lectures, and published en- yclopaedias, dictionaries and handy nexpensive manuals on mechanical rocesses or specific machines, often lustrated with suitable sketches.

It was, of course, a wholly evolu- ionary process, extending over two enturies, during which the science as well as the social structures, beliefs, abit patterns and value systems of

An International Symposium on Social, Political, Cultural and other Factors Preventing the Application of Science and Technology for Human Development will be held at New Delhi from 21-25 March 1977

hese societies were changing, deve- oping simultaneously, each accelerat- ng the other's change and providing he framework for it. But, it is interest- ng to note, how nation after nation, ike the United States, Germany, etc, eeking to modernise themselves and ridge quickly their scientific and echnological gaps, tended to draw he appropriate lessons from these levelopments.

The first non-Western nation to see in science the prospects of fulfilment of its political ambitions were the Japanese. Japan et out to achieve in only a few lecades what had taken centuries to levelop in the West — the creation of modern nation, with modern in- lustries, modern political institutions nd a modern pattern of society.

But it had to be a very different kind of exercise, of planting and earing a culture that did not evolve n its own on the Japanese soil. In- lustrialism had grown in the West with very little assistance from the tate, and scientific knowledge had lready developed far before the Western governments, barring per- aps Prussia, introduced universal ducation. But the reformers were ot daunted. They carefully analysed he factors which had brought about he scientific revolution in the West nd set out with state help to simulate avourable conditions.

The time they chose to initiate the changes was the aftermath of the Meiji Restoration. The Meiji Restoration of 1868 was like the bursting of a dam which rolled out a cataract of pent-up people's energy and enthusiasm.

Japan woefully lacked natural resources. So it shifted its emphasis from natural to human resources. It started a programme of universal general education and, for maximum benefit, the medium chosen was Japanese. It sent out 600 students and scholars abroad to collect material and study the systems those countries followed. It also imported American, German, English and French scientists, engineers and physicians to serve in its universities as teachers of aspiring scientists. The linguistic barriers were overcome by translating Western scientific text-books and by compiling a dictionary of technical words from French, English and German to Japanese.

The efforts paid handsomely. Japan today ranks among the few topmost industrialised countries in the world.

Next, let's take the Soviet Union. It, too, relied heavily on the mass enthusiasm generated by the October Revolution to push its programmes for a complete transformation of the society along scientific lines. It, too, based its strategy on the integration of science, the state and industry to achieve maximum self-reliance in solving its industrial and other problems. And, again, it, too, had for its scaffolding a science-oriented mass education, imparted, for maximum benefit, through the mother-tongue.

" One of the first steps taken by Lenin, after he had seized power ", writes an observer, " was to decree in 1919 that the entire population between the ages of eight and 50 should learn to read and write. The local Soviets were given two months to plan and organise the massive effort. They were given the authority to mobilise all teachers then not serving in the Red Army, and the right to use churches, private houses, and factory assembly rooms for the purposes of education. This work was begun at a time when the regime was fighting for its very existence. Starvation and internal conflicts were ravishing the country. The civil war had not yet been decided. Soldiers were fighting with a gun in one hand and a spelling book in the other. A commissar would attach scraps of paper with letters on them onto the backs of soldiers marching in a line, and while they were trudging toward the front, he would test the ability of those marching behind to read them. In many places they didn't even have paper or pencils. Teachers in these areas were advised to use the tips of charred sticks as writing tools."

What's more, the Soviets simultaneously carried on a vigorous programme of scientific education for the already literate. J. G. Crowther, a well-known British science writer who visited the Soviet Union in November 1930, wrote:

" In the drive for technical education every qualified engineer in the USSR was ordered to devote a part of his time to teaching. In our visits to the various technical colleges and schools, we met high civil servants with engineering or science degrees, whom we had previously met in conferences in Government offices, doing their stint of teaching. . . . We saw schools and colleges of every grade and variety, from simple craft-training to the most advanced abstract and applied research. All were working on a multiple-shift system, in order to make the fullest use of the equipment available. . . .

" Since physics was becoming very important, the Soviet Union proceeded to produce as many competent physicists as it could. In 1918, there were only 40 effective physicists left in the whole of the USSR. What the Soviet Union did was to bring them all together at the Physico-Technical Institute where they were made to conduct research and, more important, train promising young men. By 1929, 200 new physicists had been trained. But this was only the beginning. Each was then sent out to various places in the USSR to build up his own institute around his particular speciality. This helped in creating new centres of scientific culture in almost all major parts of the Soviet Union."

Crowther comments: " I saw what could be done to develop higher technical education when there was a will and the power."

The Soviet Union started with a greater time-lag than Japan. It had to catch up with nations which were not only far ahead of it in economic and industrial development, but were further widening the gulf every day with their faster pace of scientific and technological developments. It pushed, therefore, the methodology developed by Japan much further

and became, perhaps, the first nation to introduce total planning.

To give their programme the big push, all the major factors of production were state-controlled and centrally directed towards national priorities. All education, social institutions, religion, press, literature and arts, even individual and family goals as well as wars and external affairs came to be designed and directed in favour of the official policies. Redundancy was fought through constant evaluation and, where necessary, through modification of programmes and a wide variety of contingency planning. Vested interests — powerful groups trying to push their own pet programmes regardless of the social cost — were sought to be fought by bringing in people from a variety of disciplines to jointly tackle a problem; possible bureaucratic red-tapism and rigidity, too, were taken care of by creating political bodies which, on one side, continuously discussed and debated the merits and demerits of a particular programme and its apparent implementation at different stages, and, on the other, ensured its success through direct participation of the people.

The Chinese offer yet another notable example of a non-Western society which has apparently succeeded in bridging a large part of its scientific and technological gap through deliberate scientific planning. Here, again, there was total involvement of the entire population under the direction of the state, fostering both the creation and application of scientific knowledge. A massive programme of universal education was initiated both to tap the creative energies of the people and to develop their problem-solving capability. To facilitate this further, Chinese was used as the medium of instruction at all levels and the Chinese script was simplified.

The new leaders drew freely on the experiences of both Japan and the Soviet Union. But they rarely copied the established methods uncritically. Rather, these were adapted to the Chinese conditions, making use of local resources and giving full play to local initiative in solving technological problems.

The Chinese set up thousands of backyard workshops throughout the country. "The general enthusiasm which followed the re-establishment of stable conditions," writes Kurt Mendelssohn, who visited China in 1966, "after half-a-century of hunger, wars, and personal insecurity, was not allowed to die down by letting people wait for years. Millions everywhere, eager to take part in the new technological progress, had immediate opportunity to try their hand at it in the backyard workshops. By the time the big factories were built, those men and women who had proved particularly capable had received training under exacting conditions, while others who had turned out to be less adept as technicians had gone back to other occupations."

The great Yangtse bridge was started by a relatively small number of trained riveter crews. But a whole army of workers was brought in with flags and festoons to just watch and learn. And if a dam was to be built, men and women in thousands would encamp at the site, armed only with picks, shovels and baskets for carrying the excavated earth.

There was a massive effort, writes C. H. G. Oldham, to indoctrinate previously illiterate peasants and factory workers with the basic knowledge of science. Two reasons were given for this. One was that by understanding that the laws of nature could be understood by man, and used for his own advantage, the peasants would discard their old beliefs and superstitions. Two, by encouraging scientific experiment and innovation at all levels of society, the economic growth would be faster.

Needless to say, these resulted in an almost exponential growth of scientific and technological skills.

Science in China, thus, in its sense of gaining new knowledge and systematically investigating and solving problems, was being made the property of the entire people. It was used to integrate all problems of production, technology, education, medicine, social relations, basic research, planning and so on into a coherent scientific methodology.

It will be apparent from the above that science, in its application in these countries, is not merely a problem-solving device. By the use of rational, systematic thinking — itself a product of scientific culture — it has been brought within the political process and used in the formulation of national goals, in importing techniques of integrative planning, in the reform of institutions, and in the solving of almost every contemporary problem of the society through a multidisciplinary approach.

I shall not go into the details of the scientific culture as it obtains in India. It is so easy to perceive the difference between the approaches followed by these countries and our own. However, I would like to draw attention to two historical factors which have made the situation here more complex. One is the Indian caste system based on the debilitating faith in destiny governed by birth and karma. And the other is the British rule which, during a crucial period, gave the Indian scientific development a dependent, colonial slant, and from which we have still to free ourselves.

The Indian subcontinent did not go through the kind of evolutionary process that gave birth to modern science in Europe and America. It could not. During these times, the mood here was not of buoyancy and an exhilarating sense of freedom, but of self-preservation. Periodic political upheavals had created an all-round sense of insecurity. Society was stratified and segmented into cloistered castes. Faith in karma and a destiny outside human control instilled inaction. Whatever industry there was,

was stagnant. The artisans worked ither individually or in small family nits. They worked mostly to meet he limited requirements of the self-ontained rural economy. There was o mobility, no incentive either to xpand the production capacity or to mprove the quality of their wares.

The caste system effectively sepa-ated the learned from the skilled. If he higher castes went for increasing peculative abstractions and even nysticism, the lower ones, specially he artisans, gave unimaginable rich-ess to their craft in both execution nd workmanship, but stopped there.

The caste went farther. It fostered psychology of isolation. Even men elonging to the same craft seldom ot together to discuss problems. And rades and professions being here-

ditary, skills acquired remained the exclusive preserve of the particular amily, and, sometimes, died with the ast member of the family.

The situation suited the British ulers. And they tried as far as pos-ible not to disturb it. They, of course, nitiated certain programmes which ooked scientific, like their surveys of gricultural and mineral resources, r setting up of medical schools. But hey were merely to meet the raw naterial requirements of their own xpanding industries back home, or o make the day-to-day life of their dministrators and their military men afe from the hazards of the un-amiliar tropical diseases.

Introduction of English as the nedium of instruction as well as nternal communication by the British ut a further seal of separation in a ociety already riven by caste. The British took another major step of far-eaching consequence. In a perhaps eliberate bid to pervert the value ystem, they imposed supremacy of he Indian Civil Service (ICS) ureaucrats over all the other services, ncluding the educational service. Whereas in England", complained ames G. Covernton, a director of ublic instruction, before the Islington ommission in 1913, "a police officer, a local magistrate, a collector of revenue does not necessarily rank in popular estimation and actual status before a professor, a school master, or an inspector of schools, the new arrival (in the Indian Educational Service) finds the position here quite different."

The men from the educational service not only received less pay, and lower status, but they were also "regarded with disdain" by the members of ICS. Without social and official recognition, teaching members of the service came to expect little more than the bureaucratic mete of promotion, increment and pensions, and to retain them, they generally developed cautious attitudes towards all public issues and remained subservient to the administration.

Now, all this could have been changed after 1947. But what did we do after we became free? Did we take the kind of steps that Japan, Russia and China took to plan and nurture science in their lands? What steps did we take to rid the Indian mind of its obsessions with fate, the Zodiac and the pre-ordained cycles of birth and death? Of course, we had Jawaharlal Nehru's rather romantic words which read: "It is science alone that can solve the problems of hunger and poverty, of insanitation and illiteracy, of superstition and deadening custom and tradition, of vast resources running to waste, of a rich country inhabited by starving people. Who indeed can afford to ignore science today? The future belongs to science and to those who make friends with science."

But did we take advantage, like the Japanese, Russian and Chinese did, of the popular enthusiasm of the people immediately after Independence to solve these problems before they could get bogged down with problems of monetary resources? Did we attempt any kind of mass participation in development projects like building of dams or roads or in creating better sanitary conditions around the place where we lived or worked? That could have served to break down many traditional barriers of caste and religion. Instead, we strengthened the forces of obscurantism and tradition by addressing all the time to caste and parochial forces to gain political support and win elections.

The scientific culture is characterised by a greater investment in human than natural resources. And it would appear that a healthy population imbued with some kind of passion or fervour; mass literacy backed by a modern educational system which teaches to question, to analyse, to investigate and to infer; an effective library system; and an information media that continuously updates the people's knowledge, form some of the prerequisites for such a culture to flourish.

What is the state of our country today? We have the dubious distinction of having over 250 million people living in abject poverty and suffering from all kinds of avoidable sicknesses, 70 per cent of the population totally illiterate, and an educational system which, instead of stimulating, in fact deadens our intellect.

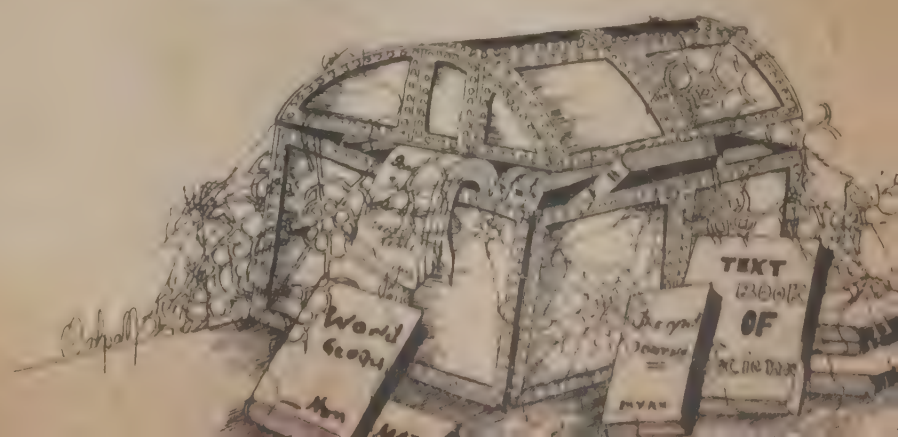
Did we, in order to tap the creative energies of the people, try to give, whatever education we gave, through the mother-tongue? We retained English as the language of both instruction and internal communication. With the literacy as it was in 1947, we could have, if we were serious about modernising our society, taken the bold step of changing over, as the Indian National Army did, to the Roman script for all languages. But we let the opportunity slip.

Although we published excellent blueprints for educational reform, we failed to change the content of our educational system. We did not teach our student the art of original thinking or develop his problem-solving ability. We did not help him discard old beliefs and superstitions. We did not encourage scientific experiment and innovation. We adhered to the old antiquated courses, to the old systems of learning by rote and passing the exams. Having not been trained to think for ourselves, and interact with our own environment, is it any wonder that we have always to look up to a guru, or to a certificate from abroad, for all kinds of things?

SURENDR JHA

[Surendr Jha is Editor of SCIENCE TODAY.

This article formed part of the text of a talk given before the Indian Physics Association (Bombay Chapter) on 7 May 1976 under the title "Scientific Culture — Here and Elsewhere".]



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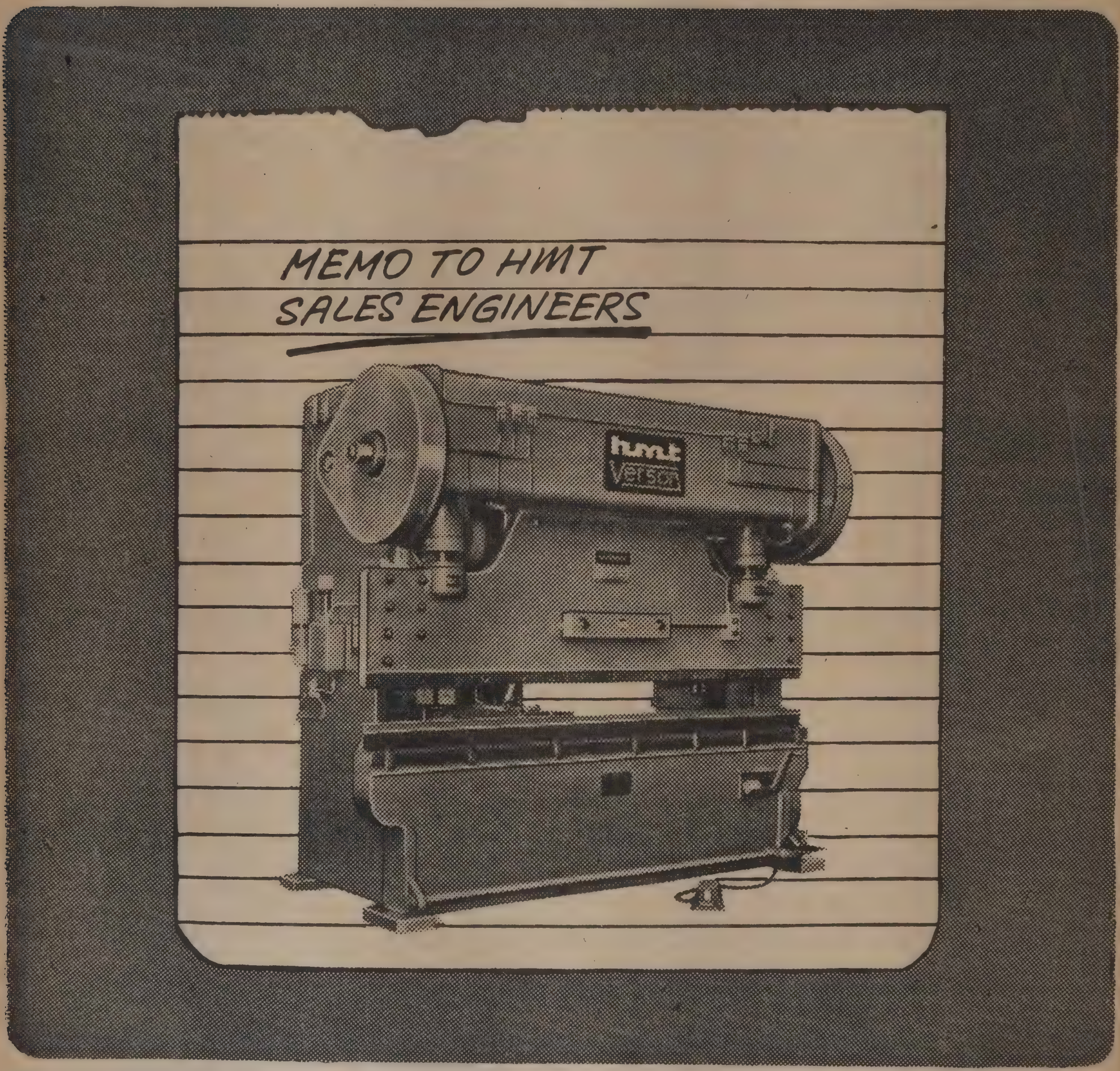

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SAA/HMT/2383

What caused the IA Caravelle with 95 on board to take that fatal fiery plunge at Bombay Airport on 2 October 1976 is yet to be determined. In the first part of this study of air accidents, the author summarises what the investigators look for and how. In the second part, SCIENCE TODAY looks at the grey zones of air safety

WHAT LIES BEHIND AIR ACCIDENTS?

BHASKAR ROY

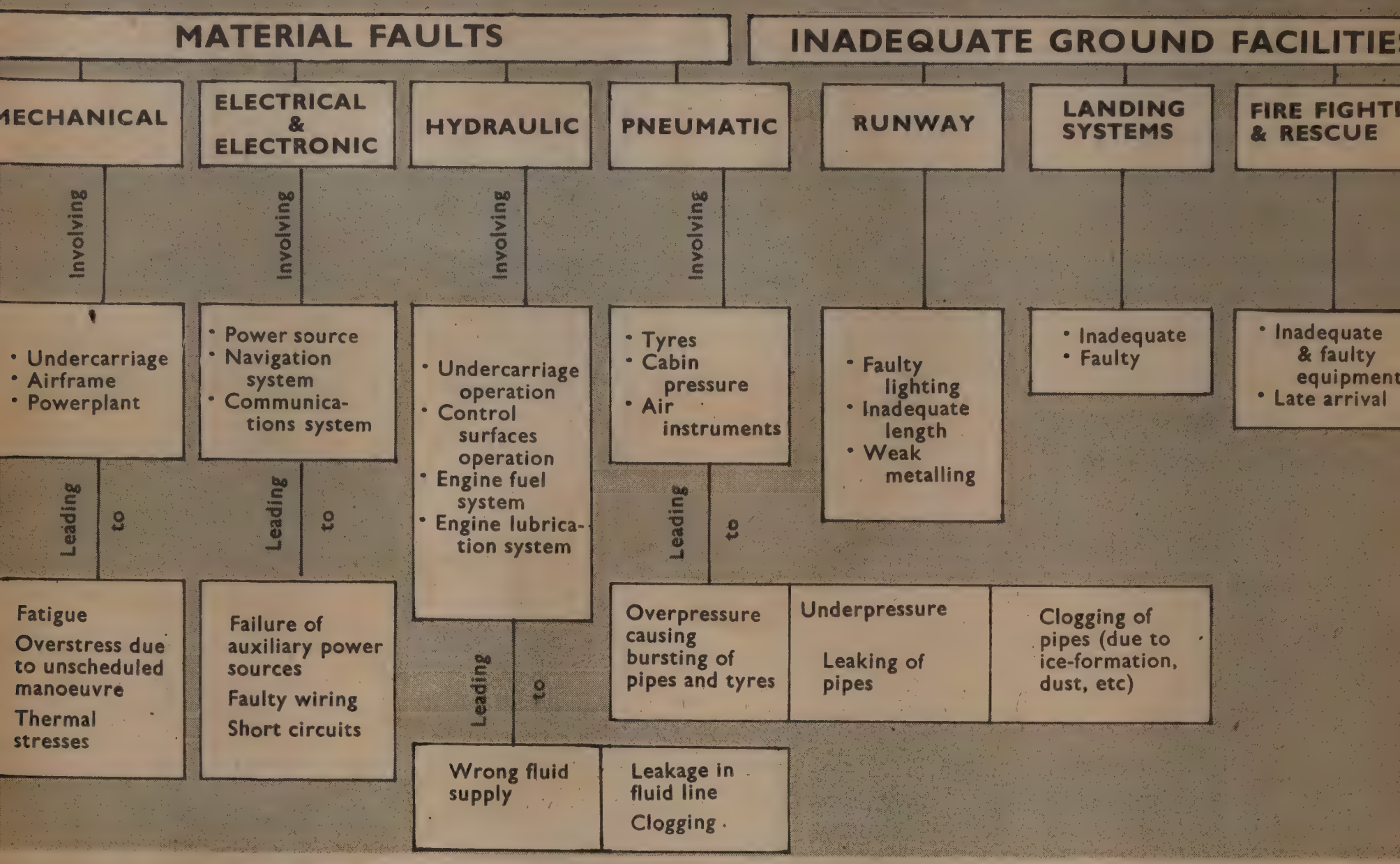
The investigation of the first air accident in which a passenger was killed took only about three seconds. The pilot knew the cause of the accident before the actual crash. The Wright brothers first went up in their flying machine in 1903. But, to obtain a government contract, it was an essential condition that the aircraft be able to carry a passenger. In September 1908, Orville Wright took off with a light-weight passenger, one Lt. Lahm, and came down safely. A few days later, Orville Wright took off with Lt. Thomas E. Selfridge, a 173-pounder, aviation's second passenger. The aircraft reached an altitude of 150 ft (45m), descended to 75 ft (23m) (incidentally, even today, the standard measure of altitude is in feet and of distance in nautical miles), and then suddenly side-slipped. Orville peered out of his birdcage seat and a single glance completed his investigation: a wooden propeller blade had splintered and cut the wires controlling the rudder. The aircraft nose-dived into the ground. Orville Wright's right leg was broken. The passenger, pinned under the engine, was killed.

Gone are those days when an aircraft was a simple affair of wooden wings, fuselage, tail and strings. Today's aircraft, running usually on jet power, is a huge affair and its carrying capacity runs into the hundreds. Its manufacture and flight involve almost every branch of science and engineering. Aircraft technicians often refer to an aircraft as "a million parts, including crew, flying in close formation".

Despite the tremendous amount of care and technical scrutiny applied to every single field of aviation, accidents do occur. Aircraft burst into flames — in air or on the ground, aircraft collide (despite the standardised procedures of 'separation' adhered to by air traffic control, or ATC, everywhere), aircraft overshoot runways, tyres burst, aircraft crash due to reasons beyond human control, or sometimes, for no *apparent* reason. We have emphasised the word 'apparent'. The 'cause' must be there, in any one or more of the several charted on pp. 26-27. The chart is a generalisation: under each heading one could add thousands of parts and components.

And then there is the human element. Aviation is not just a conglomerate of machine systems in air and on ground. It is essentially 'man in the system'. Which is why, more often than not, an accident can be traced back to a combination of human error and machine fault. Quite a few of these are liable to recur, unless the cause is identified, and the remedy found, in the quickest possible time. This is where investigation of aircraft accidents takes on a very important role.

Take the case of fire. Fire alone accounts for 50 per cent of deaths in aircraft accidents. The most common location is the engines. A fire may start from a leaking fuel pipe into the



heated portions of the engines. The routine procedure is the 'fire-drill': as soon as the fire warning comes on, all the fluids flowing into the engine are cut off and fire-extinguishers are switched on. Sometimes, the extinguishers may not function effectively. Or, the fire may knock out one or more vital instrument systems. An uncontrollable fire can spread over the whole of the aircraft, more so, if the aircraft is taking off or is in an early phase of flight, because of the enormous amount of fuel the large, modern jets carry (a Boeing 747, or Jumbo, carries about 2,20,000 litres of fuel, enough to burn down a small town). The most vivid instance of a plane turning into a ball of fire was the crash last October of the Indian Airlines Caravelle at Bombay. Often a fire is the result of a crash, after the fuel tanks have burst and the fuel spilled out. It may also have been started by an explosion, maybe due to sabotage. While the accident investigators' first job is to establish what started the fire, often it is difficult to arrive at the exact sequence of cause and effect, particularly if the crash occurred without an eye-witness.

In a multi-engined aircraft, it is possible to maintain flight with one engine shut down (but the pilot must have time to distribute the power evenly). The risk increases if the flight is in a critical phase; for

AIR ACCIDENTS

Engineering causes	% of total
Engines	27
Undercarriage Structures	23
Undercarriage Systems	9
Flying Controls	9
Main Structure	8
Instruments	5
Brakes	3
Tyres	3
Hydraulics	2
Powerplant Systems	11
	100

[After M. Morrison, British Airways' Chief Engineer, in *Flight*, 9 August 1973]

instance, during take-off, after decision speed has been achieved (after which the aircraft cannot be halted on the runway), the aircraft must be able to maintain its rate of ascent. At such a moment, an engine failure may occur due to either a bird-hit or a foreign body ingestion or a failure of accessories, like a fuel pump going out of commission. Or, a blade part may break and foul up the entire engine system. Or, there may be the maintenance engineers' eternal headache — cracks due to metal fatigue.

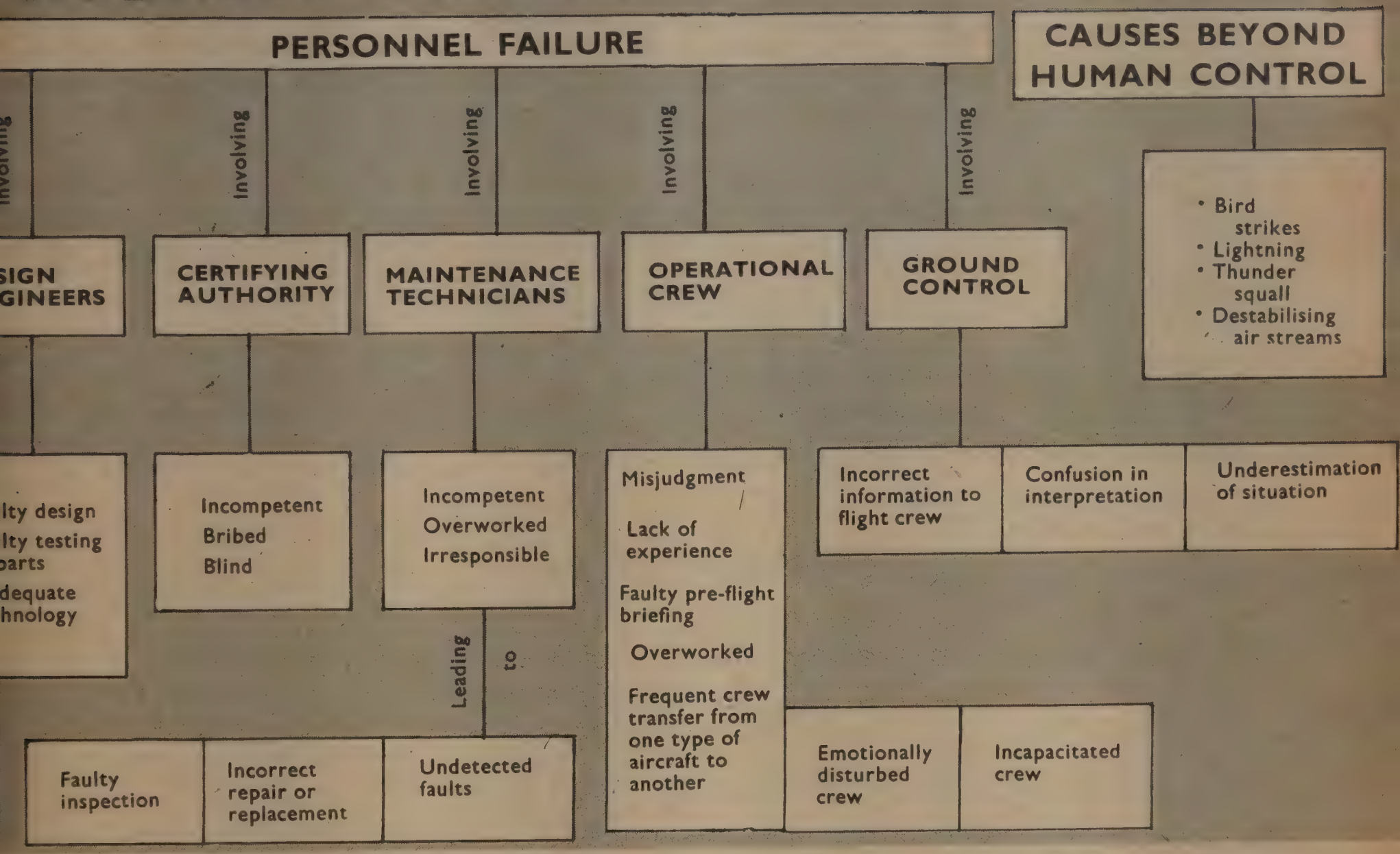
The table above shows the percentage distribution of accidents due to engineering causes.

Measures will have to be adopted to reduce the chances of bird strikes. Believe it or not, if an aircraft flying at 480 kmph hits a bird flying at 20 kmph, the impact can be of the order of 14 tons. At 1,000 kmph, the cruising speed of a Jumbo, the impact strength can exceed 57 tons, enough to rip open a wing, shatter a windscreen (and thus cause depressurisation of the cockpit and cabin; the Airbus A 300, recently acquired by the Indian Airlines, is fitted with a tested antibird-hit windscreen), or put an engine out of commission.

Incidents before accidents

In aviation parlance, it is known as the Thomas dictum: "Every accident is what happens after a series of isolated incidents". Often a catastrophe is preceded by a similar incident that went unreported — one that *could have* become a catastrophe but for chance. Sometimes during a flight, snags are noticed by the crew — maybe faulty reading of instruments, or unusual engine noise and vibration during certain transitional operations, or a passenger exit door slightly jammed and taking more time to open — which should be

PROBABLE CAUSES



reported immediately to the base and prompt attention should be given to such snags. The Turkish Airline THY's DC-10 crash near Paris in 1974, which killed 346 passengers, was caused by faulty closing of the cargo door. The pressurisation forces in the fuselage blew the cargo door off, causing an explosive decompression that disrupted the flight control systems of the aircraft. The accident, the worst in airline history, could have been avoided if attention had been paid to reports from different quarters regarding the vulnerability of the cargo door.

Or, take the case of a Boeing 727 that had sudden failure of two engines at 2,000 ft (610m). Immediate check showed the flight engineer had actuated the fuel shut-off cocks. The incident was reported. Investigation showed, during pre-flight checks, the flight engineer had acquired the habit of running his hands over the levers; during after-take-off checks, the habit persisted. The airline's immediate reaction was to "eliminate preflight checks to break the habit pattern". Later, the airline's maintenance department came up with a locking mechanism for the fuel shut-off cocks. The question is, are such improvements passed on to a central information pool so that other airlines too can benefit?

WORLD AIR ACCIDENT FATALITY (1960-1976)

Year	Accident	Fatality	Fatality per million passenger km
1960	34	873	80
1961	25	805	69
1962	29	778	60
1963	31	715	49
1964	25	616	36
1965	25	684	35
1966	31	1001	44
1967	30	678	25
1968	35	912	29
1969	32	946	27
1970	30	786	17
1971	33	975	20
1972	44	1402	25
1973	35	957	15
1974	28	1382	21
1975	17	492	7
1976	26	1332	17

(Figures for 1970-76 include those of the USSR.)

Investigations

The procedures of accident investigation are laid down by the ICAO (International Civil Aviation Organisation). Apart from its *Manual of Aircraft Accident Investigation*, the ICAO, from time to time, lays down certain procedural rules. Article 26 of the Chicago Convention states, the State of Occurrence (country where it occurs) should be the investigating authority. Annex 13 to the Convention recommends that other "interested" countries should be allowed to participate in the investigations. The "interested" countries may include both the State of Registry and the State of Manufacture, as well as countries whose nationals may have been involved as passengers. Often the pooled experience may unearth the cause sooner; often, the investigating state may refuse participation of outsiders.

It may also happen that the investigating authority may not have the forensic and pathological expertise and facilities to conduct the investigations. Or, it may lack experts to interpret the cockpit voice recorders (CVRs) and flight data recorders (FDRs). In such cases, the vital components may be sent to the State of Manufacture (ICAO Annex 9).

When a crash occurs, depending on the severity of the crash, the wreckage

may be strewn over a wide area. (The CVR of the IA Caravelle which crashed at Bombay last October was recovered from the sea several km away, several days later.) The investigators' first task is to collect and identify each available piece of wreckage before they can start asking, Why? or, How?

But answers to all the questions do not come out of inspection of the wreckage. Survivors, witnesses and experts are questioned, and yet, one may not depend entirely on the answers they give. Panic-stricken survivors, awed witnesses and over-self-conscious experts are bound to overplay or underplay in their answers; they say what they *think* they saw. Yet, the truth may be lurking behind their coloured statements. Investigators have to read not only between the lines, but between the words.

Then, there is the all important part of the aircraft — the pilot. If he made a mistake, why did he do it? What was his flying record? Was he misinformed by ground control? Was there discrepancy between ground information and his own instrument reading? What was his state of mind? Surviving crew members, FDRs, CVRs (which record the preceding 30 minutes of R/T and cockpit conversation) and ground control men may provide some of the answers. Pilot error is cited as the cause of half of all accidents. Yet, it has been repeatedly pointed out that this is an oversimplification. Often the term of reference of an enquiry is to find *the* cause, while, usually, most accidents are a combination of several causes.

Another area of controversy in recent years has been, who should conduct the inquiry? In countries like India, the inquiry board is headed by a non-expert, for example, a judge, who is aided by assessors who are connected with aviation. It is often argued that giving the verdict on the cause of an accident is a highly technical function and must be in the hands of an expert. However, there is sufficient ground to justify the present system of inquiry. Specialists are good in so far as individual points are to be answered, but to put all these into a cohesive, useful purpose, a generalist is a must. It is he who has that uncanny ability to single out a useful information out of a thousand, and co-ordinate all such leading information towards the fact-finding goal. He must start with a clean, unbiased mind, suspect everything and everybody and consider even the apparently impossible.

The public form of inquiry is a defence against rigging of the investigations. Who would be interested in rigging? one might ask. Well, it could be the airline, the aircraft manufacturer, the pilot's union, the firm manufacturing the instrument under suspicion, the government that made the regulations (which may be found to be insufficient), airport authorities (trying to suppress their inadequate safety arrangements), or it may be a powerful official behind a suspect. (From time to time, protracted legal battles are fought in courts by survivors or crash victims' relatives. Though financial damage liability is fixed by rule in

The navigational aids

In every two fatal aircrashes, one occurs during approach and landing. Most of these are due to the crew's inability to correctly judge the nearness of the ground. Lower the visibility, greater is the chance of an accident. Despite improvements in ILS (instrument landing systems), very few airports in the world are certified for Category (Cat) 3 landings; not even all international airports can claim to have proper Cat 2 landing facilities. The terms apply to instrument landing with the autopilot on. (The autopilot flies the plane along a pre-programmed pattern without the pilot's intervention.) Instrument flying is extremely helpful in poor visibility conditions as the pilot does not have to depend on visual cues for making his approach. However, the actual touch-down and take-off have to be executed by the pilot (rarely the co-pilot) manually. The better the navigational aids provided by the airport, the closer the pilot can risk descending near to the ground — minimum descent altitude (MDA) or decision height (DH) — before he can decide whether to land or fly over and try again — what is known as a "missed approach" or "go-around".

The essential condition to the decision to land is that the crew must be able to establish visual contact with the ground — the runway, if it's daytime, and the marker lights, if it's night. In this respect, the landing categories have been defined as:

Cat(egory) 1: MDA not less than 200 ft (61 m) with a forward visibility of not less than 2,500 ft (760 m) runway visual range (RVR).

Cat 2: MDA 100 ft (30 m) with not less than 1,200 ft (365 m) RVR.

Cat 3 (a): MDA 50 ft (15 m) with not less than 700 ft (210 m) RVR.

(Theoretically, Cat 3 has been further extended to Cat 3b with RVR of 150 ft (45 m). Cat 3c is defined as "zero-zero" — zero cloud base and zero visibility.)

It may take years for most airports to get equipped for Cat 3 landings. Meanwhile, there are aids available to ensure at least Cat 2 landings. There are two basic design concepts: (*a*) air derived, and (*b*) ground derived. In the air derived systems, the computations for position determination are done on board the aircraft with the help of VOR, DME, etc. This approach is favoured by airlines and pilots as it provides separate, independent means of navigation for the pilot and surveillance for the controller. In the ground-derived system, computations for position are done on the ground for both navigation and surveillance and the data are transmitted to the aircraft. Here use is made of ground-based radars like PAR, surveillance radars, etc.

An invaluable aid to landing is the visual approach slope indicator (VASI) which helps the pilot keep the aircraft on the correct approach path after completing instrument approach, just before touch-down. Bars of red and white lights on each side of the runway are so beamed by the reflectors that when the pilot is too low, he sees all red lights; when he is too high, he sees all white lights; and when he is on the correct path, he sees red and white bars one above another. Shown on the right is a diagram of a VASI/ILS landing system.

On researchers' drawing-board are microwave landing systems (MLS) which are claimed to be the system of the future.

Below is a glossary of some of the terms used in navigational aids (NAVAIDS):

NDB (Non-Directional Beacon): In the medium frequency (MF) range, this is standard aid for area navigation. Radio waves from transmitters lay down an imaginary hyperbolic lattice which can be overprinted on a map.

VOR (Very high-frequency Omni-Range) beacons: Two radio waves of constant frequency are transmitted, but one is stationary while the other rotates. The receiver in the aircraft compares the difference in phase, which is proportional to the magnetic bearing of the VOR. VOR can be coupled to the auto-pilot. A new development is Doppler VOR, in which the modulations are reversed.

ertain cases, there may be unlimited iability if wilful negligence can be roved. The THY DC-10 crash at Paris was followed by such protracted egal battles that ultimately damages had to be settled out of courts!) Evidences may be distorted, facts uppressed, important pieces of wreck-ge misplaced or removed, investi-gators lured by bribe, or the pilot nay be induced to take the blame on himself. Often the pressure is subtle nd is most effective when the in-vestigation is done by the now-familiar one-man committee or a hurriedly assembled miniature team.

Public inquiry and full publication of the report must be mandatory on all nations. After all, the purpose of the investigation is to "learn from mistakes". The ICAO publishes summary reports of accident investigations sent by all member states in the annual *Accident Digest*.

Murphy's Law

It is stated simply: it is mechanically possible to fit some parts of an aircraft in the wrong way as well as in the right way. In that case, someone, someday, somewhere will assemble it wrongly. Murphy's Law has shown its unrelenting application in practically all parts of an aircraft. A non-return valve in the fuel line was fitted the wrong way and resulted in the loss of 15 lives. A landing gear hydraulic jack was made which was possible to assemble the wrong way round; a fitter did so — and caused an accident.

It is a measure of the investigators' and designers' success that Murphy's Law has lost a great deal of its prevalence. The possible pitfalls are 'designed out', and with the 'dimmest, least-trained, most negligent, teatime-minded, creditor-chased, family-harassed mechanic' in mind, even extra parts are added.

Yet, the Law survives. In the late 1960s, a Swissair DC-9 was found to be fitted with a DC-8 nose-wheel bearing. This comes under the purview of Murphy's Law in a wider sense. Development of a series of aircraft like the Boeing 7X7 series or the DC-XD series and series engines like Pratt and Whitney JT-XD series, inevitably results in parts common to two or more types of aircraft or engines. This, of course, is an immense economic gain from the point of view of design, manufacture and maintenance. But, in the process, Murphy's Law gets a new lease of life.

DME (Distance Measuring Equipment) s a cockpit instrument. VOR and DME combined can provide the complete Navaid.

INS (Inertial Navigation System): Cock-pit instrument, which is basically a gyro-mounted platform linked to a pre-programmed computer.

PR (Primary Radar) or ASR (Air Surveillance Radar): Finds and tracks aircraft up to 300 km away.

Secondary Radar: Unlike the PR, it is not passive, but "interrogates" the transponder in an aircraft which is a radar receiver-transmitter responding on a selected frequency. If the aircraft has no transponder, the radar controller can ask the pilot to make an identification turn.

PAR (Precision Approach Radar) provides ground-controlled approach (GCA). The aircraft's position is monitored by the ground controller and steering corrections are sent through voice-link.

ILS (Instrument Landing Systems): There are two beams. The localiser beam comes from a VHF transmitter at the far end of the runway on the centre-line in the vertical plane. This is seen as a vertical needle on the ILS instrument. The glide path or glide slope is a thin beam in the horizontal plane, seen as a horizontal needle. When the needles are exactly crossed, it indicates correct approach (see SCIENCE TODAY, July 1973, p. 28).

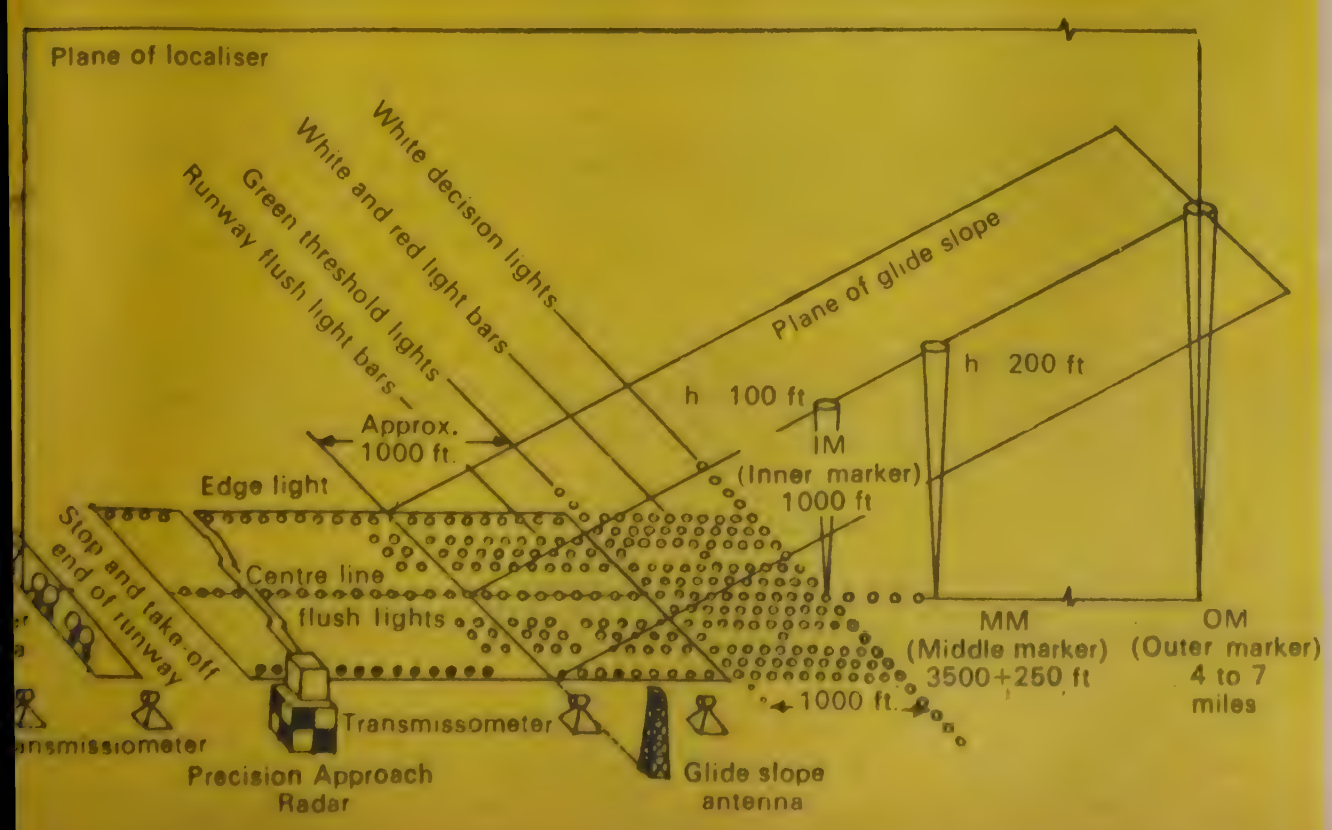
ILS begins at 1,500 ft (460 m) altitude at about 4·5 miles (7 km) from runway (outer marker) and the glide slope is 2 to 3° depending on obstacle clearance and noise abatement requirements. Visual contact must be made with runway middle marker at 200 ft (60 m) altitude (Cat 1 landing) or the inner marker at 100 ft (30 m) altitude (Cat 2 landing).

GPWS (Ground Proximity Warning System): A cockpit aid in research stage, intended to provide both visual and aural warnings.

HUD (Head-Up Display): Projects important readings on the windscreen coaming, thus allowing the pilots to avoid looking down. Not in wide use yet.

VASI (Visual Approach Slope Indicator): Airfield-in-sight aid. Bars of lights at the runway side indicate if the pilot is below the glide path, or above, or on it.

MLS (Microwave Landing System): In research stage, will give a choice of approach paths and two-gradient glide slopes. Will not require outer marker beacons and can be contained *within* the airport.



While such pooling of information does go a long way towards preventing recurrence of a tragedy, *Flight* magazine's editor, J. M. Ramsden, in his *The Safe Airline*, has pointed out some very significant lacunae in the investigation routine itself. One neglected area is medical evidence. This is important because "some accidents have been solved solely by pathology". Limited laboratory and refrigeration facilities, and local legal and religious restrictions can stand in the way of a pathologist's job. The importance of clinical or pathological tests for heart disease, alcohol or drugs is now well-understood. Several countries are now insisting on altering the Chicago Convention to include pathologists in investigation teams.

Conclusive evidence of sabotage was found from X-ray photographs which showed hundreds of metal particles in some bodies, Ramsden points out. From their size and position, it could be deduced that they had been projected at high velocity, as in an explosion. The fragments were of mild steel, used very little in aircraft manufacture. If the bodies had been made unavailable for forensic studies, the actual cause would have remained unknown. Aeromedical literature cites a curious case of an investigation which showed a crash had occurred due to pilot incapacitation when his legs became paralysed after an earlier spinal tumour surgery started bleeding. Later, pathological examination showed, the bleeding was actually caused by the crash, and not the other way round.

LIGHTNING STRIKE, despite the fears of early aviators, is a rare factor in air accidents. A *Flight* survey located only five known instances (see table below) of fatal accidents due to lightning in the past 25 years. Of these only one was a jet, a Pan Am 707, that crashed in the USA in 1963 after lightning set its fuel tanks afire; the aircraft was fuelled by JP-4 and not the safer JP-1. Good bonding makes today's aircraft proof against lightning damages. At the most, the lightning leaves only two holes at the points of entry and exit.

DATE	AIRCRAFT	LOCATION	FATALITY
27- 1-1951	S-M 95B (Alitalia)	Civitavecchia	14
26- 6-1959	L-1649A (TWA)	Milan	68
12- 8-1963	Viscount (Air Inter)	Lyons	20
8-12-1963	707 (Pan Am)	Elkton	81
24-12-1971	L-188 (Lansa)	Puerto Inca	91

"Black box"—the invaluable witness

The most important item in an air-crash investigation is the cockpit voice recorder (CVR) housed in a crash-proof and fire-proof container and located generally in the rear portion of the aircraft (see SCIENCE TODAY, January 1977, p. 74). Though known as the "black box", the CVR container is painted yellow or bright orange for easy identification and location. CVRs have four channels recording simultaneously and retain at least the last 30 minutes of the record at any time. Two of the channels record all communications sent and received (by R/T) by the first and second pilot, a third channel is connected either to the flight engineer or the aircraft's public address system, and the fourth recording from an open area microphone picks up all cockpit conversation as well as any extraneous sounds.

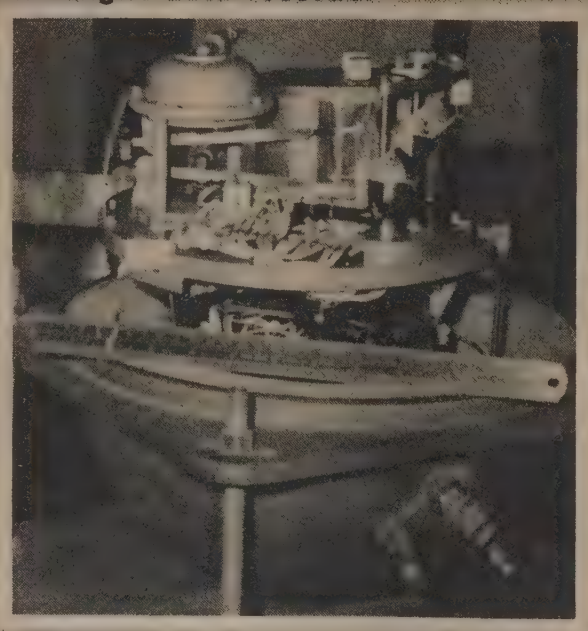
Besides the CVR, all civilian aircraft weighing over 5,680 kg and flying above 7,600 m (25,000 ft) altitude are required to carry a flight data recorder (FDR). Five parameters (airspeed, altitude, magnetic heading, vertical acceleration and pitch attitude) are recorded from the beginning of take-off run to the end of landing run. This, too, is painted bright orange or yellow. Many of today's accident data recorders are also provided with a radio beacon and fluorescent seamarker for recovery from the sea.

Advanced accident data recorders (including both the CVR and FDR) are housed in an aerofoil-shaped box which is flush-mounted on the fuselage near the tail. The tape drive and record head are held in the cavity but outside the box; only the tape cassette is held inside the aerofoil. On the first symptoms of a crash, the signal from crash detectors (transducers distributed throughout the aircraft) triggers a pulse that causes the aerofoil box to detach. The tape is smoothly disengaged from the drive as the aerofoil starts getting deployed: it is blasted out by ram air pressure and the cavity is automatically closed by spring-action doors.

The aerofoil is designed to develop sustained lift in flight, so that the trajectory takes it away from the crash. Also, it produces sustained heavy drag, which slows down the aerofoil at a very fast rate so that it does not hit the ground with too heavy an impact.

The aerofoil antenna is completely internal, surrounded by a hermetically sealed shock absorber. It has a transmitter beacon; during normal flight, the transmitter is held off by the electric potential provided by the control circuit on the aircraft. As the aerofoil gets deployed, this signal is lost and the beacon soon begins to transmit.

The flight data recorder



In backward areas, the wreckage may be looted. Which means, there is need for more public education. Even the seat cushions could be important to an investigation. In the classic case of the crash of a Comet 4B G-ARCO in the Mediterranean, a single seat cushion provided the complete proof of the presence of a bomb, its location and its type.

Days may not be far when SSTs like the Concorde or Tu-144s will become aircraft of the international routes. If a Concorde, flying 17 km above the ground and at twice the speed of sound, disintegrates, its wreckage might be scattered over a range of 100 km or more. Investigation of such incidents would need men with almost superhuman intelligence, tenacity and technical knowledge. Yet, such investigation will have to be done honestly, or else it will be a mockery of man's technological progress.

Non-fatal accidents

Some accidents may be unavoidable. However, investigations can indicate improvements that could make some crashes at least survivable. For example, investigations into several incidents of fatality from fire have shown how the fuel used can spell the difference between life and death. JP-1 has been proved to be much safer than JP-4, yet JP-4 continues to be used because it is cheaper, lighter and easily available. JP-1, consisting of kerosine, burns slower in the case of fire (its flashpoint is +40°C) and gives those valuable extra few seconds for the passengers to run to safety. JP-4, consisting of gasolene, has a flashpoint of −20°C. (JP-5, which is by far the safest of all aviation fuels, especially in hot climates, is, unfortunately, also the most expensive and the least available.)

Or, take emergency exits. One must remember that, emergency evacuation can never be simulated sufficiently realistically. Designers try to provide emergency exits whose number is proportional to the aircraft's seating capacity. The rule is: all persons should be safely out of the aircraft within 90 seconds from the seated position with seat belts fastened — that, too, using emergency lights only. Considering that every 10 seconds a passenger can jump from the emergency exit, a delay of one minute in opening the emergency door could mean a loss of six lives. After several cases of deaths due to asphyxiation inside burning fuselages, several ICAO recommendations were made regarding the kind of materials to be used in cabin fixtures.

Even the seats have come under increasing scrutiny. The average passenger tolerance of a forward impact is 25 g acceleration for just under $\frac{1}{4}$ second — this is the same load faced by a trapeze artist falling from 120m on the nets. This is the primary reason why seat belt fasteners (and nowadays shoulder-harnesses, too, as in cars) are a must. Researchers believe, the ideal seat design would be a rear-facing seat where the seat can absorb much of the "dynamic overshot". However, research in this particular area is slow due to lack of experimental data.

The Airbus recently acquired by the Indian Airlines has been equipped with some of the most advanced safety features — probably distilled from decades of accident investigation experience. On the flight deck, a unique computer tells the crew exactly what control settings are needed

AIRLINE ACCIDENT RECORD INVOLVING FATALITIES

ACC.: ACCIDENTS FAT.: FATALITIES

rline	Country	1960-70		1971		1972		1973		1974		1975		1976	
		Acc.	Fat.	Acc.	Fat.	Acc.	Fat.	Acc.	Fat.	Acc.	Fat.	Acc.	Fat.	Acc.	Fat.
roflot (85)	USSR	1	33	2	117	3	384	6	270	1	118	1	28	5	415
rolineas (1·3)	Argentina	4	123	—	—	—	—	—	—	—	—	—	—	—	—
ro Mexico (2·2)	Mexico	2	10	—	—	—	—	—	—	1	38	—	—	—	—
r Algerie (1·0)	Algeria	3	71	—	—	—	—	—	—	—	—	—	—	—	—
r Canada (9·7)	Canada	5	232	—	—	—	—	—	—	—	—	—	—	—	—
r France (7·6)	France	8	593	—	—	—	—	—	—	—	—	—	—	2	3
r India (0·6)	India	1	117	—	—	—	—	—	—	—	—	—	—	—	—
italia (5·9)	Italy	5	186	—	—	1	115	—	—	—	—	—	—	—	—
merican (21·1)	USA	3	159	—	—	1	2	—	—	—	—	2	29	1	37
l Nippon (—)	Japan	4	191	—	—	1	162	—	—	—	—	—	—	—	—
itish Airways (12·7)	UK	5	258	1	63	1	168	1	4	—	—	2	5	1	176*
lta (24·6)	USA	4	43	1	4	1	88	—	—	—	—	—	—	—	—
stern (26·2)	USA	5	233	1	2	1	100	—	—	1	70	1	113	—	—
aruda (1·4)	Indonesia	4	83	—	—	1	3	—	—	1	36	1	17	—	—
eria (9·0)	Spain	5	137	—	—	1	104	1	69	—	—	1	27	—	—
dian Airlines (2·8)	India	9	181	1	20	1	18	2	59	—	—	—	—	1	95
n Air (1·2)	Iran	1	4	—	—	—	—	—	—	—	—	—	—	—	—
pan Airlines (8·8)	Japan	2	8	—	—	—	—	—	—	—	—	—	—	—	—
LM (3·2)	Netherlands	2	81	—	—	—	—	—	—	—	—	—	—	—	—
fthansa (7·4)	W. Germany	3	52	—	—	—	—	—	—	1	59	—	—	—	—
A (0·8)	Pakistan	7	209	1	4	1	33	—	—	—	—	—	—	—	—
an American (10·4)	USA	7	174	1	4	—	—	2	81	2	203	1	1	—	—
AS (6·2)	Scandinavia	2	57	—	—	—	—	—	—	—	—	—	—	—	—
wissair (4·3)	Switzerland	3	131	1	1	—	—	—	—	—	—	—	—	—	—
HY (2·2)	Turkey	3	15	—	—	1	1	—	—	2	412	1	42	1	155
WA (14·1)	USA	8	268	—	—	—	—	1	1	2	181	1	33	—	—
AA (3·6)	Australia	3	38	—	—	—	—	—	—	—	—	—	—	—	—
nited (30·3)	USA	8	268	—	—	1	43	—	—	—	—	—	—	—	—
rig (2·3)	Brazil	5	179	—	—	—	—	2	125	—	—	1	3	—	—

[The list does not include all the airlines in the world. Also, it does not include unpublished accidents. Numbers in bracket indicate ssengers carried in millions by the airline in 1973.] * Mid-air collision. Figure includes 113 passengers of Inex-Adria DC-9.

to lift the plane into the air at peak efficiency at whatever combination of air temperature, runway length, altitude, wind velocity and direction, and other parameters, while keeping continuous electronic check on safety margins throughout the take-off, even in the case of an engine failure. Another important safety device is a highly sophisticated bad weather automatic landing and go-around system (which gives it a Cat 3 landing certification). The automatic go-around during the landing approach can be initiated — even with one engine functioning — from 15 ft (4·5m) at the push of a button on the throttle, without touching the ground.

The hydraulic system, which operates the vitally important flaps, ailerons, rudder and landing gear, comprises three fully independent operating circuits, operating simultaneously. The three circuits provide triplex power for the flying controls, so that if any circuit fails, full control of the aircraft is retained without the pilot's intervention. The hydraulic fluid is a fire-resistant phosphate-ester type. The fire protection system is self-contained and fire-wall panels are designed to protect the main structure from a fire. The eight abreast 2-4-2 seating ensures that no passenger is away from the aisle by more than one seat; this means during emergency, evacuation would be faster. Another unique feature of the Airbus is the bird strike-proof windscreen glass.

Safety — what is the measure ?

Statistical proofs, of course, will not convert people who possess an obsessive fear of air travel. Actually, a comparative calculation was done by Sir Peter Masefield of Britain a few years ago. He estimated that, if a group of 100 people were using each of the five modes of transport for 8,000 km a year, we could compute the time each group must travel before one of them could expect to get killed:

Rail	1,540 years
Bus	1,000 years
Aircraft	370 years
Motor car	133 years
Motor cycle	7 years.

The tables (above and on p. 27) show air accident fatalities by airlines and the total world fatalities every year. However, statistics can be misleading. A survey of some of the well-known airlines in the world shows that no set pattern of accidents can

be evolved. Fatality record of all the airlines together shows that 1972 registered not only the highest number of accidents but also the highest number of fatalities in the 17-year period between 1960-76 (strangely, 1975 was the safest year). Yet, shown against a popular fatality record parameter—fatality per million passenger-kilometre—it is much lower than in the 1960s. This is because the airlines are travelling farther with more passengers in bigger aircraft. Hence, though more men and money have been lost, the record would show a better performance.

On the other hand, bigger airlines are bound to have higher accident records. Consider the 17-year survey between 1960-76. Indian Airlines and Aeroflot have the highest number of fatal accidents. Yet, since Aeroflot operates bigger aircraft, carries more passengers and has a much bigger network, its chances of meeting accidents are much more than IA's. Again, Air India has one of the best records with only one fatal accident in 17 years. Compare this with TWA's record which shows 11 accidents ; but TWA carries 25 times the number of passengers carried by Air India with a network almost ten times bigger.

To get a clearer picture of airline accident record one has to consider not only the fatalities per passenger km but also the number of departures, size and type of aircraft used, along with the passenger growth and increase in network over the years.

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"Why all this fuss about air safety? A quarter of a million die on the roads in a year, compared to a thousand or two in airlines. When you ask for safety, you are asking for aircraft with the proven reliability of an Apollo spacecraft, and pilots trained like astronauts, and something like the NASA ground control. But, then, who will foot the bill?" Thus spoke an aviation expert as we began this inquiry. Is it purely a question of finance?

IC-171, Indian Airlines' evening flight from Bombay to Madras, became a proxy flight on 11 October 1976 — in more sense than one. The flight that was to start at 6 PM with a Boeing 737 aircraft began at 1.40 AM of the next day with a Caravelle, after the 737 was found to have a hydraulic snag. The co-pilot rostered for the 737, Capt. V. Nambiar, did not have endorsement on his licence to fly Caravelles (the pilot, Captain K. D. Gupta, did) and Capt. K. L. Prasad was called in. Unlike Boeing 737s, Caravelles require a flight engineer. So Mr. F. E. Warden was called in. The 737 was to carry 108 passengers; Caravelles can carry 89, so 19 (among them many airline pass-holders) were off-loaded.

The Caravelle (registration mark VT-DWN) was made by Sud Aviation of France (now known as Aerospatiale) and possessed the valid certificate of airworthiness issued by the Director General of Civil Aviation (DGCA). It had 258 hours flying time left till the next thorough check was due. It had landed after a Delhi-Bombay flight at 10.30 PM. The pilot had reported a low level in the hydraulic fluid tank. The tank was belly-drained and no leak was found. The night-time routine intensive inspection, known as Transit B check, was carried out according to schedule approved by the DGCA and was certified by a DGCA-approved maintenance engineer. The inspection was done on the tarmac.

It would have been another routine flight. The pilots possessed the required pilot-in-command (PIC) licence — which has to be renewed every six months after proficiency checks by the DGCA — and had gone through refresher courses which are not mandatory, but are conducted by the airline once a year. Capt. Gupta had flown 10,656 hours as pilot-in-command (1,920 hours on Caravelles) and 3,441 hours as co-pilot (484 hours on Caravelles). Capt. Prasad had flown 10,585 hours as pilot-in-command (2,200 hours on Caravelles) and 7,121 hours as co-pilot (512 hours on Caravelles). Mr. Warden had flown 5,802 hours on Caravelles. In the mandatory six-monthly medical fitness check-ups, they had been certified fit — Capt. Gupta and Mr. Warden by the Central Medical Establishment (of the Air Force), Delhi, and Capt. Prasad by the Institute of Aviation Medicine, Bangalore.

An hour before an aircraft's departure, the airline's flight despatchers file the flight plan — which gives the proposed take-off and flight path, destination and desired altitude, number of passengers, time of departure, aircraft type and call sign — which is given to the airport Control Tower and air traffic controllers (ATC) 20

A layman often wonders about the distinct functions of a flight crew. There are the pilot, the co-pilot, the flight engineer the navigator — they make up the cockpit crew — and the cabin crew consisting of hostesses and stewards. The cabin crew's function is to look after the passengers comforts, render assistance when required acquaint passengers with emergency evacuation drills and organise evacuation in the event of an accident or emergency.

The cockpit crew's function is mainly to keep the aircraft's flight under control. The navigator looks after nagivation so that the aircraft flies along its charted course. In short-hop flights — as for example in the Indian Airlines routes — navigators are not required as the pilots can fly the aircraft by ground-based beacon aids. The flight engineer is responsible for 'nursing' the aircraft systems — the engines, the hydraulic, the electrical and the electronic systems, etc; in some aircraft, he may also handle throttles at specified times. In some types of aircraft, like the Boeing 737, the flight engineer's function is integrated within the pilots' control instrumentation and hence Boeing 737s fly without a flight

nutes before departure. In the cock-, the crew go through a detailed e-flight check, which consists of the ght plan, flight clearance certificate, eteorological (Met) clearance, radio d aircraft systems. The aircraft is aded within the permissible limit veight of passengers + luggage + rgo + fuel) and the pilot signs the imsheet and the doors are closed.

The ATC Centre gives clearance to art engines and taxi to runway. The TC Centre is responsible for provid-g required separation (between fferent incoming and outgoing air-aft) while taking aircraft out of the rminal area and for specifying the rway and levels at which to fly — y naming the runway, VOR naviga-on beacons and the levels at which fly over them. Once the aircraft as reached a certain height, it is ven the frequency for communicat-g with the Approach Control. When reaches an altitude where it won't nflict with other aircraft, it is anded over to Area Control. Area ontrol looks after its safety from that ltitude till it reaches cruising level. The Approach Control radar can onitor up to a radius of 50 nautical iles and up to 15,000 ft, or 4,560 m, ltitude. The Precision Approach adar, or PAR, has a radius of 15 to 0 n. miles (1 nautical mile = ,853 m.)]

Actually, an aircraft in flight is ever out of touch with the ground. he whole of India has been divided to four zones — Bombay, Delhi, alcutta and Madras — which pro-ide Flight Information Service (FIS) all aircraft flying over. Then there is Flight Advisory Service (FAS) within the zone which can give information and advice if requested. When an aircraft approaches with the purpose of landing, it is taken over by the Area Control Service and is bound by its instructions. The flight to Madras would have been taken over by the Madras Area Control before it could begin actual descent. The Area Control would check other traffic, give descent clearance up to, say, 9,000 ft (2,735 m) (7,000 ft, or 2,130 m, for outgoing aircraft), and when 80 km from Madras Airport, the aircraft would be handed over to Madras Approach Control, which would give clearance and guidance for approach, and provide information about weather and runway conditions (to prepare for any emergency). Approach Control provides control up to the point of visual contact with runway, or if the aircraft is landing with PAR aid, till it has landed. Every aircraft carries a detailed map of the airport which shows visual cues, obstacles with obstacle clearance limits (OCL), location of beacons, etc. If there is heavy traffic, the ATC arranges aircraft in sequence, or what is known as "stacking" — separation of 1,000 ft (300 m) vertical, or if on the same level, 10–15 minutes flying time. As each aircraft is given approach clearance, all the others are told to descend

neer (the pilots are paid Rs. 15 extra hour for this).

e pilot is the captain of the craft and es total responsibility. It is he who t ensure that all pre-flight checks have carried out according to the proce-, the loading has been done according he trimsheet plan, the aircraft systems functioning and that the number of engers tallies with the passenger list is, there are no stowaways). The pilot execute both take-off and landing ually. In foreign airports, if the airline not have a representative, he may have to handle the financial formalities landing fees, etc.

e co-pilot's function is to assist the . During take-offs and landings, he monitor the instruments and make outs, handle radio-telephone (RT) link the airport control and look after in other functions like switching the channels (as instructed by the Tower), cting and lowering the wheels, etc. The ilot is fully capable of handling the aft. His presence becomes invaluable n the pilot is faced with an emergency there is sudden pilot incapacitation.

PILOT TRAINING

In Air India, pilots who have done 1,500 hours of flying in command in twin or multiengined aircraft (1,000 hours if they have jet experience) are selected for training (at Bombay) to fly Boeing 707s as co-pilots. After six weeks of technical training, the pilot is required to pass an examination conducted by the DGCA. Successful candidates are given simulator training for 40 hours — 20 hours from the pilot seat and 20 from the co-pilot seat. Then they go on to 8 to 10 hours of flying in aircraft. After the DGCA endorses their licences for 707s, they are sent on all Air India routes under supervision of senior pilots. A minimum of two flights on each route is given. Then they begin flying as first officers (co-pilots).

To go into command, they are chosen as per seniority. After refresher courses (technical training and flight safety), there are 20 hours of simulator training followed by 8–10 hours of local flying. Then the pilot is sent under supervision with DGCA approved check-pilots for about 300 hours on routes. The pilot is then brought back for pilot-in-command (PIC) test conducted by the DGCA. Once a pilot gets his PIC certificate, he is sent to East African, South-East Asian and Gulf routes. After sufficient experience as commander, he qualifies for the European sectors.

The training programme for 747s is similar. The seniormost 707 captains and first officers qualify for 747 captains' and co-pilots' vacancies, respectively.

There are also periodic proficiency checks, refresher courses and route checks twice a year.

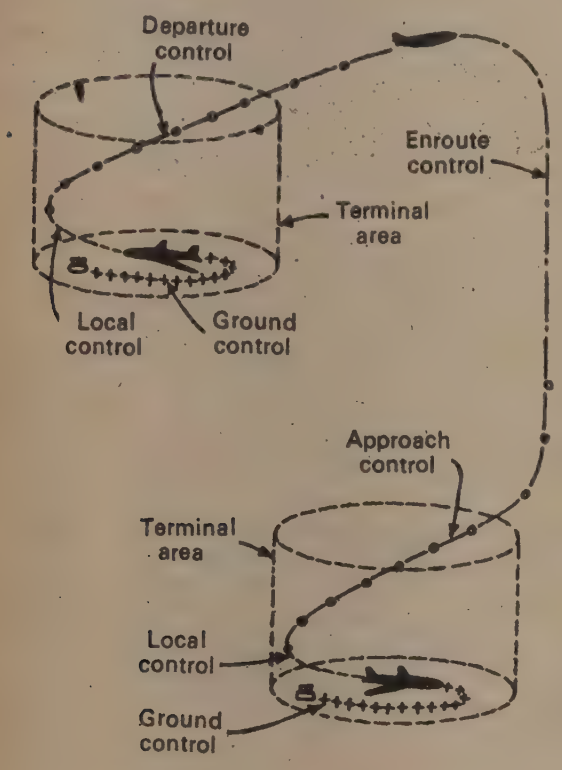
The pilot training programme of the Indian Airlines (at Hyderabad) is run on similar lines.

When an airline acquires a new type of aircraft, a batch of pilots and instructors are sent to the manufacturer's establishment for training. After successful completion of several weeks' training, the pilots and instructors return to fly the new type of aircraft and train other pilots at home. Most airlines prefer to train their pilots on simulators or cockpit mock-ups initially. There are two reasons: (a) it saves fuel and expensive aircraft need not be exposed to risks, and (b) not all emergencies can be "simulated" on the aircraft.

Advanced simulators, like the one for Boeing 747 at the Air India Training Establishment at Bombay (shown here), are computerised and programs can be fed to simulate all possible emergencies', including weather turbulences; giant hydraulic jacks produce the roll, pitch and yaw. The trainee pilot's flying 'performance' is automatically charted so that he can study his 'mistakes' later. Air India's 747 simulator will soon be equipped with a 'visual aid': night-time approach views of the world's major airports can be projected on the windscreen.

However, not all airlines can afford such advanced simulators. (Air India's 747 simulator cost Rs. 3 crores.)

by 1,000 ft (300 m) and so on. After the incoming aircraft is cleared for landing, the pilot is given his altimeter setting, and finally, an Approach Director vectors it, by heading and altitude instructions, to the beams of the ILS. The ILS gives the pilot a safe instrument landing approach; if there is VASI (see box on p. 28), it gives the correct glide path to the runway.



The radar hand-off from one Area Control to another during an aircraft's flight

The Caravelle which took off from Bombay Airport at 1.40 AM on 12 October would have landed at Madras 1 hour and 50 minutes later. It didn't. Within seconds of its being airborne, the pilot radioed the Tower he had engine failure; 35 seconds later, the pilot radioed an engine was on fire and he was returning to land. The aircraft was already on the outward westerly turn over the (Juhu) sea when it made a sharp left turn and approached the runway. Eye-witnesses could see it as a ball of fire, and then the plane nose-dived from an altitude of about 300 ft (91 m) and crashed into the ground.

What went wrong? We shall not know until the Inquiry Commission, headed by Justice S. B. Bhasme, submits its report (it hasn't at the time of going to press). A few details stand out — more as puzzles than clues — from the affidavits and cross-examinations of witnesses during the hearings so far. These are:

● According to Mr. V. Chellappa, Director of Air Safety, the Indian Airlines maintenance records showed some of the major components and assemblies of engine and airframe were beyond the prescribed life.

● Mr. G. V. R. Nair, Engineering Manager (Quality Control), IA, admitted some defects noted in pilots' Service Defect Reports were repetitive and a few persisted even after correction. These involved fuel and autopilot systems, starboard engine fuel-flow gauge, and hydraulic tanks.

● According to Capt. V. R. Moghe, Senior Pilot, IA, neither the cockpit voice recorder (CVR) tapes nor the ATC tapes recorded the fire alarm which is very loud. The alarm (including a blinking red light) comes on if engine temperature exceeds 450°C. CVRs were fitted on IA Caravelles only recently, between July and September 1976.

● Capt. Gupta, who was IA's Deputy Operations Manager in charge of operations duty for emergencies and problems, had flown a Caravelle flight to Madras and back (IC-171/172) and returned at 2 AM on 10 October 1976. On 11 October, he was in office from 9 AM till 4 PM and was back at the airport to take the 6 PM flight to Madras. He, ultimately, took off at 1.40 AM on 12 October.

● According to Capt. H. P. Kanade, General Secretary, Indian Commercial Pilots' Association, the Caravelle and Boeing cockpit designs are different and the fire-drill is also different: in the Boeing, a single switch activates five different cut-offs, while the Caravelle has a multi-switch system. This may require an extra 5 or 6 seconds — very valuable seconds in an emergency.

● The CVR was fished out of the sea by two fishermen. How it got there is still a mystery.

● The CVR tape has a recording of Capt. Gupta's voice saying he "was feeling sleepy" (this was quite sometime before take-off).

● The area mike of the CVR which records all cockpit conversation and noise has a mysterious blank from zero to 82 digits, or about 55 seconds.

● The CVR tape shows two thuds — one could be the nosewheel going up but the second, louder one cannot be explained.

● The CVR tape shows Capt. Gupta had used the R/T (radio-telephone) for giving the engine failure call. Normally, such calls come from the co-pilot who handles the R/T while the pilot handles the aircraft.

● Capt. Gupta was given pre-flight medical check-up (for alcohol) at 5.20 PM on 11 October. Capt. Prasad and Mr. Warden were not given the pre-flight medical check-up. IA's explanation was that, due to shortage of manpower, and because no Bombay-based pilots normally took off after 7 PM, the pre-flight medical check-up was done only between 5.30 AM and 7 PM. The decision to call in Capt. Prasad and Mr. Warden was taken after 10.30 PM. Also, an IA circular says, a flight should not be delayed if a medical officer does not turn up in time.

● Preliminary study of the aircraft's flight path has shown Capt. Gupta had handled the aircraft with exceptional skill, especially in lining the aircraft with the runway after the turn-back which involved possibly a 60° banking turn.

● Post-mortem report by Dr. C. A. Franklin, Bombay's Police Surgeon, said chemical analysis had shown no alcohol in the crew's bodies. (According to Capt. H. P. Kanade, when some pilots arrived at the wreckage site, they saw only a few crushed limbs in the cockpit wreckage. The flight engineer's body was found some 15 metres away from the cockpit wreckage; possibly, he had been sent to the rear

FDTL — a two-edged sword?

Flight and duty time limitation (FDTL) was introduced in IA in 1965 after the Justice Khosla National Tribunal Award. It specifies the number of hours a pilot may be asked to fly (65 hours per month and 6½ hours per day on a jet and 80 hours per month and 8 hours per day on turboprop) and the mandatory rest period between two flights. One provision says, if a pilot starts a flight before 9 PM and lands after 12 midnight, he should not be rostered for another flight till 48 hours after. At the hearings of the recent Caravelle crash inquiry, the ICPA pointed out that Capt. K. D. Gupta had returned from a flight at 2 AM on 10 October 1976 and hence rostering him for the scheduled 6 PM flight on 11 October was a contravention of the rules.

However, pilots themselves may contravene safety procedures to avoid the FDTL mousetrap. If a flight has been delayed, they use extra power to beat the 12 midnight deadline so that they do not get rostered out for the next 48 hours. Every flight means an extra allowance of Rs. 101 (also another Rs. 15 per hour for Boeing 737s). Or, if a snag cannot be immediately corrected by the maintenance personnel (at a transit point), the pilots would rather let the snag be carried forward and fly the aircraft, than ground the flight. A similar compulsion might work in not making a detour in bad weather conditions.

he aircraft to assess the extent of in the tail-mounted engine.)

Also, post-mortem of passengers' lies showed very little ingestion of oke, indicating that the fire may have entered the passenger com-rtment considerably before the sh and the deaths were probably e to the crash impact.

Only the statistician mains unimpressed. In his book of ures, fatality per million passenger n flown has come down from 197 in 50 to 7 in 1975. The terrible nose-ving, fire-balling 95 deaths in Bom-y on 12 October 1976 will only ift the figure by a few decimal aces. The statistician's optimism les the tip of the ascending graph airline ticket sales. It won't happen me, every traveller thinks. May be t; no aviation man — manufac-rer, flier, the man on the ground or the airline's maintenance hangars will treat 'safety' as a game of ce. But then 'safety' can be a aded dice.

Why do accidents occur? Aircraft e built for safety. It is said, the esign engineer's ideal is a proba-lity of failure as low as one in a llion. But, then, there is the human ement that no one can guarantee, espite all the years of training, all e accumulated experience, despite l the checks. The human element volves both the flying crew and the en on the ground, and any slip nywhere can have a cumulative ffect. Or, when an emergency arises t of causes beyond human control, e margin of safety gets measured by e calipers of human response, especi-ly of the men in the cockpit.

ncommon causes

May be one cannot do much about auses beyond human control, like eather effects which include thunder-orms, clear air turbulence, lightning, rosswinds, or wind shears (see box on 36). The safety margin depends on ilot experience — how well they are ained to learn to avoid a danger and ow well they can cope when con-onted with one. Many airlines use mulators that can duplicate several ypes of weather situations. Today, irdstrikes have become so common between April and October 1976, IA ights recorded 40) that 17 countries e now meeting in the UK to evolve ethods of bird control in airport reas.

he pilot

Half of all air accidents are said to due to pilot error; a majority of

> "I agree that this [difficulty in operating two types of aircraft] is a serious matter, but I have never protested because I have resigned to my fate. This resignation of mine might affect the safety of passengers. I know it....There was no use of my doing so, because all facts are personally known to people who belong to the management."
>
> — Capt. V. R. Moghe, senior pilot, IA, at the hearings of the Justice Bhasme Inquiry Commission.

these take place during landing and take-off. Despite improvements in aircraft design and navigational equipment, actual touch-downs and take-offs have to be executed manually by the pilot. Bad habits and lack of skill can spell the difference between danger and safety (despite the periodic proficiency checks and refresher courses). These are:

● Pilots who have entered jet flying from older propeller aircraft, take time to get used to instrument flying; most of them are still "seat-of-the-pant" fliers. A US National Transportation Safety Board (NTSB) study done last year on ILS accidents during 1970–75 has shown, almost every mishap occurred after the crew had seen a visual reference and was trying to transition from instrument to visual flight procedures. The main bad habit is failure or laxity in monitoring all flight instruments according to regulations. On 12 November 1975, a Eastern Airlines Boeing 727 crashed at Raleigh, NC, USA. The aircraft encountered heavy rain, along with probable downdraft, and a slight horizontal wind shear as it descended below 200 ft (60 m). The pilot's descent profile was upset and he failed to execute a "missed approach"; he lost sight of runway in heavy rain below decision height. The co-pilot, it was found, did not make loud, distinct call-outs of altimeter reading.

● Often, though a pilot is required to execute a "missed approach" if the last call-out does not come (it comes after establishing visual contact with runway), he still tries to land. Why? Is it due to overconfidence? Or, if he is a senior or an executive pilot, from pride? Or, could there be a subliminal pressure from the management to save on fuel?

Take the instance of the DGCA's strong indictment of a senior pilot's (who was also IA's Deputy Operations Manager then) action in executing a hazardous landing with a Boeing 737 at Hyderabad on 12 April 1974 despite the co-pilot's advice against it. During the stop-over, another senior pilot not only dissuaded ground personnel from conducting checks for 'heavy landing', but took over control of the subsequent flight to Bombay without filing a new flight plan with the Begumpet (Hyderabad airport) ATC. The former pilot's explanation (for the risky landing) at the enquiry was, he wanted to "save on fuel".

● Discussions with ground controllers have revealed some similar situations of pilots attempting hazardous landing despite Control Tower report of bad weather and advice to fly to another airfield. Airport Control Tower personnel also recount instances of planes taking off with brakes jammed, when the runway may be under a thin film of water, or landing and overshooting the runway — what is known as "aquaplaning".

● A common bad landing incident is "heavy landing", or too early touch-down. Or, there may be premature use of spoilers. These are lift-dampers, used to bring full aircraft weight on

An aircraft comes in to land as a thunderstorm spirals in the distance. While most aircraft are fitted with storm-warning radars, and pilots are advised to make radar detours, "flank tornadoes" — at the outermost edges of the big thunderstorms, sometimes inside innocent-looking clouds — are not always detectable by radars

Courtesy : "FLIGHT"

the wheels on the runway, especially on wet runways. During descent, these may cause too early a descent. During take-off, if the spoilers are retracted too late, overshoot may occur.

● The flight data recorders (FDRs) can point out such hazardous pilot habits. But regular monitoring of FDRs cannot be adopted by most airlines as pilot unions resent the FDRs as a "big-brother" snooper, as it was revealed at the Flight Safety Seminar held in London in December 1976.

Among reasons for pilot *error*, some are:

● The common landing condition — (called Cat 1) 200 ft (60 m) altitude and 1,500 ft (450 m) runway visual range — allows just 25 seconds to establish visual contact with the ground and to decide to land or not. In the ILS approach, errors may creep in if there is interference from structures or faulty calibration. In Cat 2 landing, which Jumbos (Boeing 747s) are equipped to do, the time-interval for decision making is only 2 seconds.

● Particularly dangerous are low-altitude illusions — from rain on the windshield, false orientation cues from streaming lights (seen from the corners of one's eyes), etc. In aged pilots, the danger may be in intermediate vision — between eye reference point ahead and the instrument panel — if the accommodation has been disturbed.

In recent years, pilot error is increasingly being linked with physiological causes. (See SCIENCE TODAY, April 1969 and September 1972.) These could be:

● Oxygen lack, carbon monoxide, alcohol and other drugs affect brain function. It is statutory that the crew must not have consumed alcohol within 12 hours prior to a flight. Most aircrew are aware of this, but they are not aware of how long it takes for the body to wash out the alcohol's effect. There is what is known as the "cocktail syndrome" — not drunk but confused and unreliable in mood and behaviour. There may be depression, agitation and short-term memory — the pilot does not remember what he did five minutes before. Thus checklist, take-off and landing instructions may not be fully grasped. Time perception damage may impair flying memory and distance of runway may be misjudged. A single dose of alcohol at sea level has nearly double-dose effect at higher altitude.

Drugs like antihistamines cause drowsiness and neural depression, reduce alertness and affect perceptual skills. Nasal decongestants may increase heart beat rate (tachycardia). Transquillisers depress responses. Stimulants hamper memory.

● Decompression sickness (in swimmers it is known as 'bends') can result from sudden fall in pressure at high altitudes. Such cockpit pressure changes can occur due to broken windscreens from high soaring bird-hits or hail.

Pilot fatigue does not appear in any accident list, though it may be a contributory factor after long and difficult flights. If a flight terminates after midnight, sleep cycle is upset. It is said, crossing of several time-zones in long intercontinental flights may upset the body's circadian rhythm. Different body systems take different times to adapt — from a few hours to two weeks — to more than five hours time-zone difference. Flight schedules are adjusted as far as possible, but the picture is still not clear. (An interesting finding from the BOAC study at Nottingham, UK, is that intermittent flashes of light may, in fact, protect the circadian rhythm.)

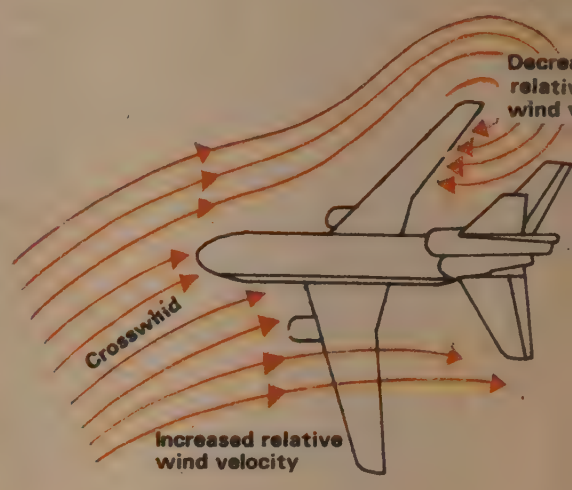
Then there is the modern concept of fatigue which says it is not a continuous decline in mental function but more frequent and abrupt blockages in the higher mental functions, not perceived by the person concerned (like while reading a book, one suddenly doesn't remember what one has just read).

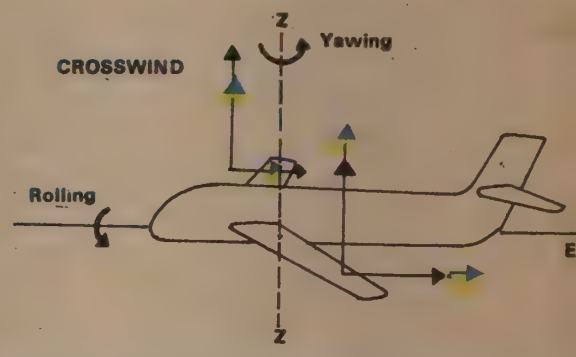
In training pilots for modern aircraft, months are spent in reducing the sequence of operations into a routine. The routine gets upset if there is information overload, or if there is a systems failure and criticial information stops coming in. Even the alarm signal may upset the pattern. Once the pattern is upset, any stimulus is foreign and may call forth involuntary reflexes. Or, there may be the opposite reaction of a "freeze-up" or no-action.

As landing and take-off are critical

WIND EFFECTS

CROSS WIND: During an air current at an angle to the flight path, the wing on the other side of the fuselage experiences a full or partial backflow or eddy, resulting in a differential lift and drag; this produces rolling and yawing.





Bird-hits

Approach and take-off are the critical phases, when aircraft can't take much evasive action. There is not enough clearance, and unlike piston engines, jet engines do not immediately respond to a sudden demand for extra thrust or power.

Among several suggestions to reduce the risk are:

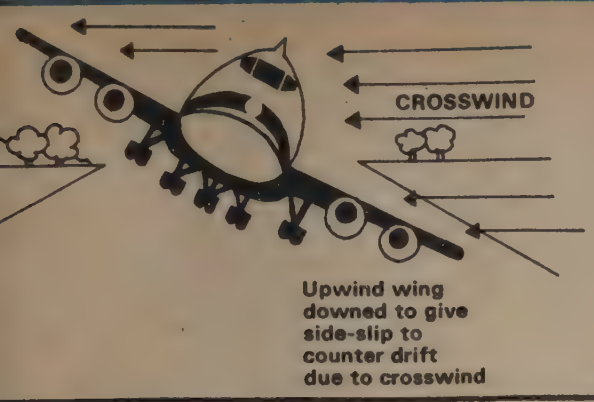
● Stop aircraft and restaurant garbage from being dumped in the vicinity of airports.

● Initiate studies to forecast bird migration (migratory birds are a problem in Delhi).

● Eliminate food-bearing plants and rodents from the vicinity.

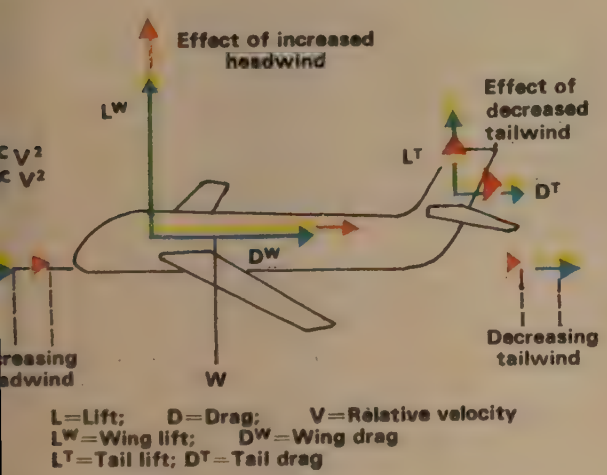
● Dredge or fill marshes.

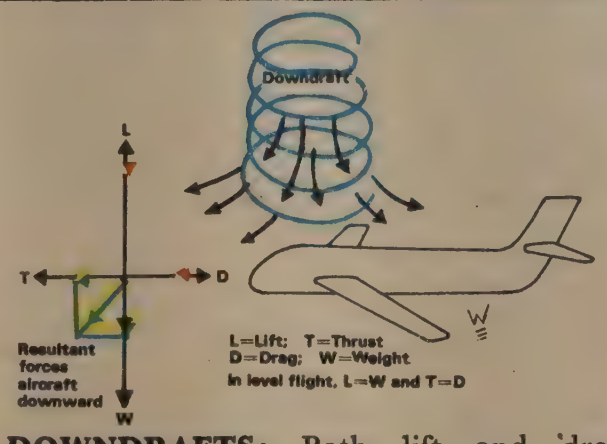
In Bombay, vultures that soar on the rising air currents around the Trombay Hill are a menace. Nobody knows what to do about them.



IND SHEAR : When an aircraft flies into a high velocity current (generated by, say, a localised depression) with ly part of it in the high velocity region, it experiences a ere imbalance in lift and drag forces on the two sides. In reme cases, it may just shear in two pieces.

EADWIND & TAILWIND: Tail-lift ances the pitching moment created by g-lift around centre of gravity. Increas-/decreasing headwind/tailwind upsets the ance and the resultant pitching moment es a nose-up or nose-down attitude. A lden increase in headwind or decrease tailwind at the moment of landing puts nose up and the aircraft lands on the l. A sudden decrease in headwind or rease in tailwind puts the nose down h a thud and the nose landing gear may eak.





DOWNDRAFTS: Both lift and drag decrease and the aircraft accelerates downward. To maintain flightpath, the pilot increases the aircraft's pitch attitude and adds thrust to rise up relative to the downdraft.

THUNDER SQUALLS: As an aircraft approaches the storm, it meets the outflowing wind as an increasing headwind. As it passes below the storm and through the peak downdraft, there is a sudden decrease of headwind. This becomes dangerous because, the pilot may already have reduced power to counter the initial increasing headwind effect and may be power-deficient when he meets the downdraft. **B.R.**

Pilot error or human error?

Though in accident statistics, of 250 accidents to five types of subsonic jet transports in about 25 million flying hours, half have been attributed to pilot error, pilots disagree. They think design error, aircraft failure due to poor maintenance, and poor ground facilities are as much responsible. After all, a third of the same 250 accidents have been attributed to engineering failures.

Design deficiencies are difficult to pinpoint. Unless an airline operates a particular type of aircraft for some time, it may not discover where the problem lies. It happened with the AVROs in the late 1960s. The aircraft was said to be underpowered and pilots experienced difficulty in taking off with full prescribed loads; often the duration of flight would be longer than the stipulated time. Later, modifications were made to increase engine power.

It is a common practice for manufacturers to deliver an aircraft to an airline and later on suggest modifications which can be bought as kits. Some airline officials ruefully call it a way of "making money on re-orders". However, design modifications are routine in any technology. The IA Caravelles were grounded in

nctions, pilots complain that there lack of understanding on the part regulatory bodies when they lay wn duty hour specifications. For ample, in an eight-hour flying riod, an Air India pilot may do only e landing and take-off, while an IA lot, flying short-hop routes (with, aybe, less sophisticated type of air-aft), may have to do four take-offs d landings.

Pilot incapacitation in flight is a re phenomenon and need not be zardous, as the co-pilot should be le to take over the flight. The most mmon cause of such incapacitation not heart attack as is commonly lieved, but stomach complaints d other alimentary disorders. An ALPA survey of 5,000 international lots listed the complaints in this der: nausea, vomiting and abdo-nal pain — 1,042 times; acute diar-oea — 450; earache and blocked rs — 153; faintness — 120; head-he and migraine — 118; vertigo d disorientation — 68.

With increase in air traffic and with wer types of aircraft, the need for perienced fliers increases. This means, senior pilots in their late 40s or early 50s are the ones most likely to be chosen. While the senses are said to dull somewhat with age, experience is a strong balancing factor.

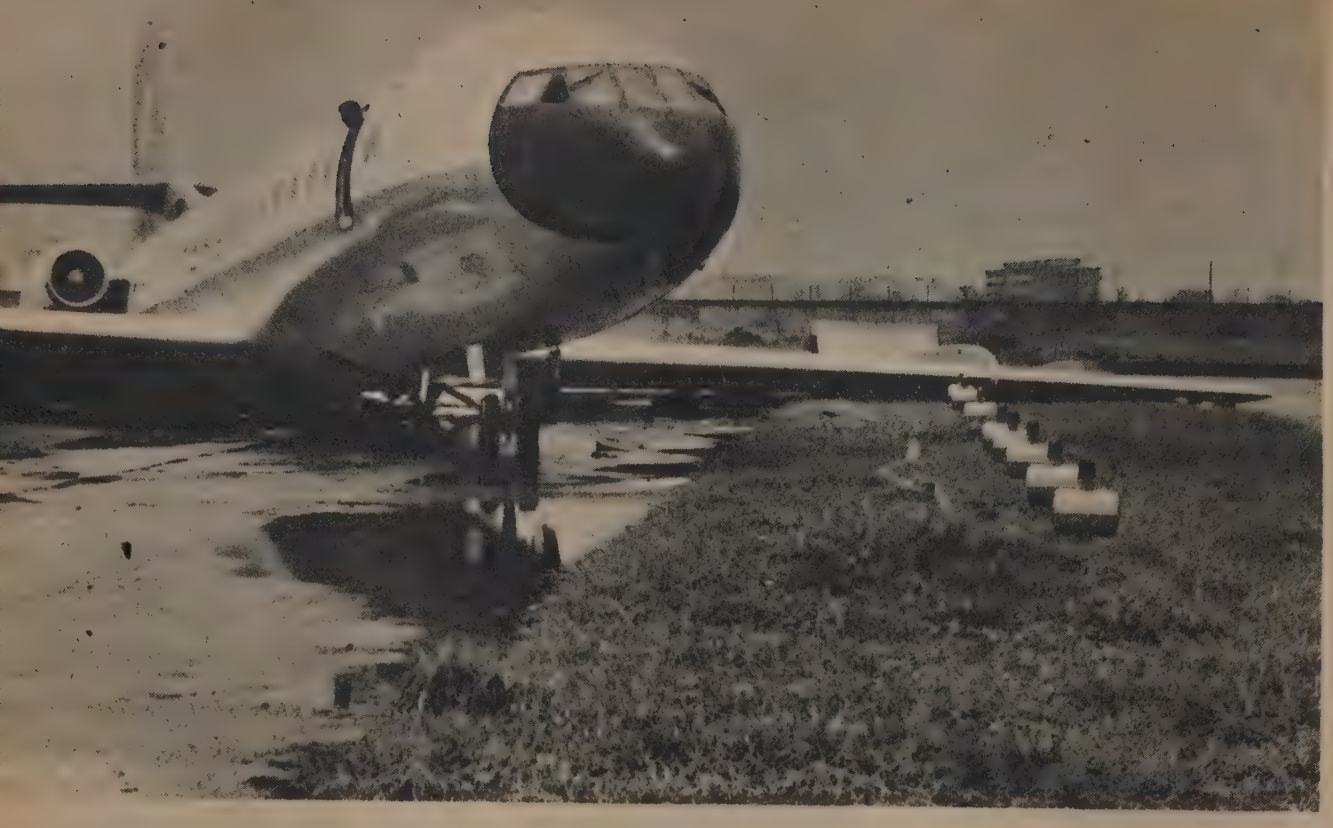
Frankly speaking, there is no substitute for experience. In the early 1970s, when Japan Airlines (JAL) expanded its operations considerably, there were a spate of accidents. Enquiries showed, the level of experience of its commanders was low. Today, JAL is said to have recruited a number of American pilots on contract.

While it is clearly acknowledged that incidents precede accidents, all over the world, incident reporting is still a problem. At the Flight Safety Seminar held in December 1976 in London, it was pointed out, some countries make it mandatory, while in others it is voluntary. However, pilots are reluctant to report incidents for fear of ridicule or disciplinary action by airline. Airlines are also afraid of the information being used against them. One solution suggested is to preserve anonymity, as done by the IATA in its Incident Exchange.

Cockpit indiscipline

On 11 September 1974, an Eastern Airlines DC-9 crashed at Charlotte, North Carolina, USA, as it was about to land; 72 of the 82 people on board died. The US NTSB investigation established that "poor cockpit discipline" was the primary cause. The "black box" tape showed, during the approach, the pilot and co-pilot had indulged in irrelevant discussion — "from used cars to politics". During the final 35 seconds, they were talking about "location of an amusement park tower", during which the aircraft descended unobserved by the crew below assigned altitude. The crew had failed to make the required call-outs of airspeed and altitude and had also ignored the aircraft's terrain warning alert. The NTSB noted, "this may be indicative of the attitudes of many other pilots who regard the signal more as a nuisance than a warning".

Another crash attributed to cockpit indiscipline involved a North-Western Airline Boeing 727 near New York on 1 December 1974. The NTSB report says, failure of flight crew to turn on pilot head heaters resulted in a "complex sequence that resulted in an undetected stall while the aircraft was on instrument flight". The crew were so involved in their personal discussions that they failed to "react to erroneous airspeed and Mach indications that had resulted from a blockage of the pilot heads by atmospheric icing".



An aircraft that overshot the runway at Bombay Airport. It could have been due to 'aquaplaning', burst tyres or faulty landing (or, maybe, faulty take-off). During 1975-76, there were at least four instances of scheduled passenger aircraft overshooting the runway in Indian airports. Instances of tyre bursts number five. There were three cases of major but non-fatal fire in aircraft on the runway; of these, in one instance, an Air France 747 was burnt to ashes at Bombay on 12 June 1975; another major disaster was averted by Bombay Airport's ATC on 9 November 1975 when a British Airways 747 caught fire at Bombay just before take-off. (Another example of how ATC alertness can avert disasters was on 30 November 1975 when an Air France 747 was about to land at Bombay's smaller Juhu runway by mistake.)

October 1976 (*not* as a sequel to the Bombay crash) for carrying out modifications (originally proposed by the manufacturer in 1973), and are now said to be undergoing tests before being reintroduced.

At the other extreme, manufacturers may not pay heed to snags reported by airlines and continue to market their products. A sad, eye-opener account of such callousness has recently been published by a London *Sunday Times* reporting team in *Destination to Disaster*, which is the story of what went on before and after the tragic Turkish Airline's DC–10 crash near Paris in March 1974.

Maintenance is another side of the coin. The warning issued by the Engineering Manager of the IA to the maintenance personnel (see box) is a sad, indirect though, admission of how half-heartedly safety can be treated in our maintenance hangars.

Then there is the MEL. It stands for minimum equipment list, a procedure evolved by the DGCA and IA, by which the Airline is permitted to "carry forward" a snag for 72 hours of flying time, as long as certain minimum equipment are in working order. Though the MEL may be prepared in consultation with the manufacturer, it can work tricks with safety. Besides, the "carrying forward" can get carried forward much further in an airline like IA with a multiplicity of short-hop routes and different engineering bases (for instance, Caravelles are serviced in Bombay and Boeing 737s in Delhi). Now, say, a Caravelle reaches Delhi and the pilot reports a snag. Since Delhi is not its engineering base, the maintenance engineer there may not have the spare and the aircraft may be asked to fly on until it reaches its home base in Bombay. Meanwhile, it may be detailed for flight to, say, the eastern sector. Since the total flying time allowed for "carry forward" is 72 hours, even five or six sector flights, with the snag still there, will still be within the permissible period.

Even major bases may not have the spares. It is known, on 7 October 1976, the (Delhi) Ground Engineers' Association of the IA had sent a communication to the Director of Engineering (IA) about the paucity of manpower, facilities, equipment and spares at the maintenance stations.

Earlier, an IA pilot could refuse to fly an aircraft certified by the maintenance engineer as fit, if he personally believed it to have some snag; the Operations Manager would decide if he had done right or wrong. This facility was withdrawn in August 1976.

WORLD AIR SAFETY RECORD

Country	1953-62			1963-72		
	Fatal Crashes	Killed	Rank	Fatal Crashes	Killed	Rank
Australia	6	68	1	2	50	2
Belgium	8	244	10	3	17	6
Brazil	32	657	11	12	298	13
Canada	18	261	7	11	364	8
France	33	908	9	13	532	12
W. Germany	4	46	5	3	79	5
India	28	220	13	12	351	14
Italy	8	239	12	7	158	7
Japan	2	36	4	10	583	11
Netherlands	6	267	6	None	None	1
Scandinavia (Denmark, Norway, Sweden)	4	62	2	3	86	3
UK	35	818	8	16	949	9
USA	94	2,406	3	91	2,449	4
Country A (Middle-Eastern)	5	66	14	7	279	15
Country B (South American)	15	394	15	5	78	10

In the above safety ranking by *Flight*, Netherlands emerge as the safest. India has slumped from a lowly 13th rank during 1953-62 to a still lower 14th during 1963-72. Australia's safety record is attributed to the country's good weather and tough air safety regulation — a long-established system of mandatory defect and incident reporting with strict follow-up action. (Australia has been described as a 'police state' in its air safety regulation and enforcement!) The Scandinavian record is also remarkable when we consider that SAS is a triple-nationality airline and that its home bases are among some of the worst flying terrain and weather in the world

INDIAN AIRLINES, BOMBAY

rom :
ngineering Manager (Q.C.),
ndian Airlines, Bombay

To :
All Categories of A.M.E.s/ARMEs,
approved personnel of Bombay Region

Cat : Mandatory Effect : Immediate
Ref : General Obj : Reminder

lef : No : EB/QC/CM/GEN-3/3675
Dated : 23rd August 1976

Sub : Standard Aviation Engineering Practices — second caution notice

In continuation of our Notice No. EB/QC/GEN-2/2048 of 3-6-76, it has become essential o re-emphasise the necessity of strictly following standard aviation practices.

During the investigation of recent incidents, cases are coming to light of further devia- ions from standard aviation engineering practices. Some staff have been found to indulge n serious deviations viz. :

(a) Certifying inspection/examination/rectification/physical work done by someone lse in his absence, as if so done by himself during his absence, thus issuing false certificate.

(b) Causing someone else to certify what one has done, thereby wilfully passing the buck.

(c) Certifying for the sake of completing formalities without in any way ensuring com- pliance of assigned task wilfully and without any consideration for safety of aircraft.

The above are just a few examples of improper practices. They are to be discontinued with immediate effect as unsafe. No amount of lame excuses can right a wrong. Safety can be jeopardised by such unwarranted behaviour.

The prime object of our profession is SAFETY. All errant staff are hereby cautioned most vehemently to desist, nay, abstain from such malpractices and cultivate a proper and correct approach to the assigned tasks. There will be no condoning for laziness, carelessness and indifference. The truth can never be hidden, it dominates and prevails in the end, and re- percussions for these will indeed be severe.

YOU HAVE BEEN CAUTIONED.

Sd/-
Engineering Manager (Q.C.)

The aerodromes and air traffic control

The Civil Aviation Department maintains about 85 aero- dromes in India. Less than half are ouched by the scheduled services. According to pilots of both Indian Airlines and Air India (who touch he four metropolitan airports), the ground equipment is not up to the tandard (though they are all praise for the ATCs). Only six airports have LS (Bombay, Calcutta, Delhi, Mad- as, Hyderabad and Gauhati; the irst four are said to be equipped for Cat-2 landings); airports with VOR nd PAR are fewer. Even the ILS quipment are said to be old and not well maintained or have faulty cali- ration. (Hills, tall buildings and igh-tension wires can also interfere.) The main problem is cost. A single ILS unit, excluding installation, costs nearabout Rs. 30 lakhs. And there is lso the question of priority. Gauhati Airport had to be provided with ILS ecause of the hills on three sides, the eavy air traffic and the uncertain weather conditions in that region. Ahmedabad and Nagpur are said to e the next two airports on the roposed ILS list.)

Many pilots feel, the worst airport leficiency is lack of glide slope in- ormation, either visual or electronic, specially at night. Then, even several odernised airports rely only on non-

directional beacons (NDBs) as a let-down aid. NDB can become erratic if radio static (atmospheric or other electric disturbances) interferes. NDB should be only a back-up to the outer and middle marker. Besides, all run- ways used for night operation should have high-intensity runway lighting, approach lighting, and flashing lights for obstructions.

Often, the pilot's estimation of the situation and judgment rely upon information furnished by the ATC. The pilot needs current information about wind, pressure changes, tem- perature, and storm proximity, move- ment and intensity. Yet, a common complaint voiced by Indian pilots is about the Met information provided by the ground control which is several hours old. Another complaint is that, only two 'route frequencies' (radio channels) out of 11 are assigned to internal flights for communicating with area controls. Often the traffic is so heavy (Bombay area has 52 route crossover points) that pilots have to wait several minutes before they can get in on the radio channel.

The fire and rescue services, too, should be adequate and well-trained. Recent safety seminars have suggested,

Body of a victim from the Fokker Friendship crash at Delhi on 12 August 1972. What do they feel just before they die? Moira Johnston in her *The Last Nine Minutes: The Story of Flight 981* — which is a psychologist's reconstruction of passenger and crew behaviour during the final moments of the Turkish Airline's DC-10 crash near Paris on 3 March 1974 (346 died in the crash caused by decompression due to a cargo door blowing off) — suggests there is initially a " startle reflex " with hands, arms and legs snapping out and muscles tensing, " as if instinctively trying to hold the plane up ". Though most would not panic, some might scream, but most would sit silent in an almost catatonic state. " Senses would become extra sharp, seconds would stretch into detail-filled, vivid hours ". As the initial shock passes, clues would be looked for " with possibly a sense of relief and hope ". For some there would be the " compulsion to act, to overcome the danger "; later, when nothing can be done," they might hurl hostility towards the pilot and the crew : ' Why don't they tell us what's happening ? ' " As the plane dives downward, there may be for some a " sense of anticipation, of exhilarated fascination with 'What will it be like ? ' " Crossing this final threshold, Johnston suggests, can bring " a remarkable sensation of detachment, an extra- ordinary sense of peace, calm, and total painlessness ". . . .

there should be back-up fire and rescue organisations from areas outside the airport to cater for a major disaster.

In the long run, then, the question of finance does crop up. The US Federal Aviation Administration says, ". . . for the financially embarrassed, the temptation to cut corners in maintenance, training and other areas vital to air safety is very strong". In his exhaustive survey, *The Safe Airline*, Ramsden echoes the thought: "Air Safety is proportional to the money an airline is prepared to invest in it". Regulations set only the minimum standards. The law does not require an airline to buy an air-borne flight-data monitoring system to measure both pilot and aircraft performances such as take-off speed, flap settings, climb, cruise, descent and landing speeds. But such a system can not only allow training methods to be changed, but also correct individual 'bad habits'. And the maintenance engineers would be happy to compare the reported snags with data tapes. "Air safety begins not in government departments, important though regulations and inspectors may be, but in the boardrooms of the financially strong airlines", Ramsden suggests.

In the final analysis, more than finance, it is honesty that matters — both in the airline that maintains safety and in the regulatory body that monitors safety. It has been noted, if the airline appoints its own medical officer to conduct pre-flight medical check-ups (for alcohol), that person is open to brow-beating. Again, it has been noted, the DGCA cannot afford to have highly-paid check-pilots on its list and often the check-pilot is loaned by the airline itself. It would be better if we could eliminate any possibility, however remote, of pressurisation being effective. (The Tata Committee had recommended in 1974 that proficiency checks and licensing of pilots should be done by an independent flight inspectorate of the Civil Aviation Department, and not by the airline.) However, it may be noted that, after the tragic Boeing 737 crash at Delhi in 1973 (in which Mr. Mohan Kumaramangalam died), all PIC licence-holders in India were subjected to an "assessment check" and few, very few, were found to be below the mark.

Maybe, the ultimate watchdog of air safety is the passenger who flies in an aircraft, though he is rarely conscious of that role. Except when an accident occurs. In the lobbies of air safety seminars, from time to time one hears groans against "newspaper sensationalising" — "one dark headline and one terrible photograph wipping out years of work put in [by safety experts]". It is ironical that one should read cross-purpose in what is unquestionably a common goal — to give those dark headlines and terrible photographs the same probability as the one idealised for aircraft components failure — one in a billion!

PRADIP PAUL

[Pradip Paul is an Assitant Editor with Science Today.]

INDIAN AIRLINES AND ITS PILOTS

Of the 450 pilots with IA today, 48 are executive pilots. The rest are line pilots. The story dates back to 1964–65 when the ICPA (Indian Commercial Pilots' Association — the IA pilots' trade union body; the corresponding body for Air India pilots is known as the Indian Pilots' Guild, or IPG) began pressing for promotion by 'professional seniority', that is, by flying record in command — number of hours flown, accident-free record, fitness, etc. In 1967, a seniority list was mutually agreed upon by the IA and ICPA, with the provision for 8–10 executive pilots who would be required to handle administrative responsibilities also, but that promotion would be on the basis of professional seniority.

However, in the aftermath of strikes in the early 1970s, the cadre of executive pilots was enlarged so that they could fly the aircraft in the event of a line pilots' strike. However, ICPA alleges, in the actual process of selection, junior pilots were taken into the cadre.

When the question of selection of the first batch of 18 pilots to be trained at Toulouse for the Airbus came up, the ICPA insisted that line pilots be included in the batch. On 1 April 1976, ICPA was informed by the IA management that among the 18, 4 would be line pilots, and if any of them failed to qualify, he would be replaced by another line pilot. However, ICPA alleges, when the final batch went to Toulouse during the last quarter of 1976, all 18 were executive pilots.

After the pilots' strike, the ICPA claims, line pilots have lost much of their say in reporting snags, accepting aircraft which they consider unsafe, and also in participating in accident investigations.

The IA management contends that these are procedural matters and do not in any way affect safety. The ICPA's contention is, they do, since they affect line pilot morale and cause frustration.

The IA management, time and again, has pointed out several instances of pilot indiscipline over the past decade. During the AVRO incidents, there were a number of cases of pilots walking off aircraft leaving the passengers stranded. There were also many instances of mass sick-leaves.

Use of language

Confusion in language and terminology can lead to collisions and other accidents. On 10 September 1976, a British Airways Trident and a DC-9 of the Inex-Adria collided in mid-air near Zagreb, Yugoslavia, killing 176. It has been suggested that possibly the Yugoslav aircraft crew were speaking in Serbo-Croat, instead of English — the official international aviation language.

The US FAA has recently published a new glossary of ATC terminology which includes definitions for a radar arrival. On 12 March 1976, a Cessna 172 had an accident at Oakland, USA, as the Cessna pilot, landing on instruments, said "beacon", referring to the radio beacon, while the ground controller thought he was speaking about the rotating beacon (implying the pilot had the field in sight) and cleared the Cessna for landing.

e Baobab's Mesozoic Brotherhood!

n his charismatic, self-illustrated fairy tale *The Little Prince*, the famous aviator-author Antoine Saint-Exupery had drawn one tration " more magnificent and iring " than all the others in the k — of three baobabs eating up little planet whose keeper had d to watch out (we have repro- ed the drawing below). " When a matter of baobabs, that always ans a catastrophe ", warned the e prince.

ANTOINE DE SAINT-EXUPERY

True, in the plant kingdom, the obab (genus *Adansonia*) is the one rsed with ugliness. A bottle-shaped nk, throwing up gnarled toes as if were planted upside-down, it is " a liban of a tree, a grizzled distorted l goblin with the girth of a giant, e hide of a rhinoceros . . . ", as ote an early naturalist. The baobab s another peculiarity — it is native ly to the African savanna (between ° N and 25° S), the Madagaskar d Kimberley in north-western stralia (elsewhere it is an exotic). d that makes it a geoscientist's pet! an article in the *New Scientist* (27 nuary 1977), Dr. Patrick Arm- ong of the University of Western stralia suggests, a clue to the ontinental drift ' — the tectonic ate movement that is *supposed* to ve caused the breaking apart of the uthern landmass known as Gond- naland to form South America, rica, Australia and Antarctica — ght lie in the grostesque baobab.

In the absence of more viable geological proof, the scientist could search for "Gondwanic elements in the flora of the now widely separated lands of the southern hemisphere ". Dr. Armstrong claims to have found some in the baobabs.

A tree like the baobab ought to inspire folk lores. And the more ancient the lores, the older must be the tree's nativity. (A few people consider even some of the living trees to be over thousands of years old; carbon-14 dating of the inside material of a tree at Lake Kariba in Africa has placed its age at $1{,}010 \pm 100$ years!) And the lores Dr. Armstrong has collected are all confined to Africa. Like in Senegal, they believe dead members of a tribe of artists, poets and singers, the griots, must not be buried in the ground but in the hollows of baobab trees to protect the soil's fertility. A Bushman tale tells how God gave each animal a tree and the hyaena was late and got the last one, the baobab, and in disgust planted it upside-down. In some African regions again, the baobab is a fertility symbol: in the Limpopo Valley, rock paintings show women with baobab pods instead of breasts. The Arabs thought the tree had magical (spirits gather under the twisted branches!) and medicinal properties and took it along on their trade routes to India and South-East Asia.

According to Dr. Armstrong, till now, in terms of biological links, Australia has appeared to be closer to South America and South-East Asia than to Africa. It is possible that many other links — of Gondwana flora — may have become extinct. A few that still survive are the flowering plants Proteas and Banksias (Proteaceae) and the thatching weeds (Restionaceae). Amongst the surviving fauna one could count the flightless ratite birds — ostrich, emu, rhea and cassowary. The baobab family may have been more widespread at one time, but had shrunk its range either due to the continental drift itself (without a corresponding shift of climatic belts) or due to competition with other plants, or both.

So, after thousands of years of cursed living, the "Caliban of a tree " might be in for a few friendly pats!

P.P.

"So, there was intelligent life on Mars after all!"

TELL US WHY...

. . . when we press the knuckles, we hear the familiar 'rap'?

In the joints of the knuckle bones, there are air sacs and when we press a joint, the air is suddenly released giving rise to the 'rap'. This is something like the 'pop' we hear when buds of certain plants are pressed. It takes some time for the air to refill the sac. This is why, once a knuckle has 'popped' out, you have to wait a while before you can have the pop again.

. . . everyone wants to sing in the bathroom?

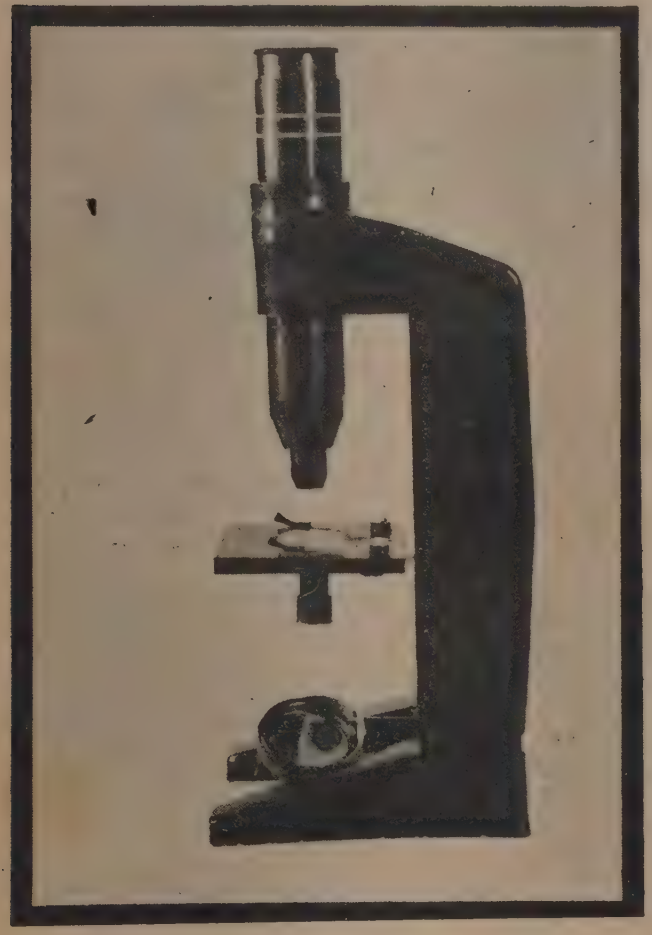
Probably, the water cools the nerves and one is more relaxed and at ease inside the bathroom. But there's a still more important reason : one is pleased with one's voice in the bathroom. The bathroom, being small, acts like a resonator, enriching an even otherwise poor voice. In open spaces or big rooms, the vibrations are absorbed without any resonance.

Consider an untrained singer. In the initial stages, lack of practice and hence poor adjustment inhibits the complete vibration of the vocal resonance area. Through training, the singer adjusts the inner resonant cavities until the optimal resonance is achieved. The singer, so to say, notices a certain resonance tickling on his palate which is due to the feedback effect that leads to the adjustment of the vocal apparatus of the larynx through nervous excitation.

For the bathroom singer, as the bathroom is a good resonator, the feedback arrives already enriched.

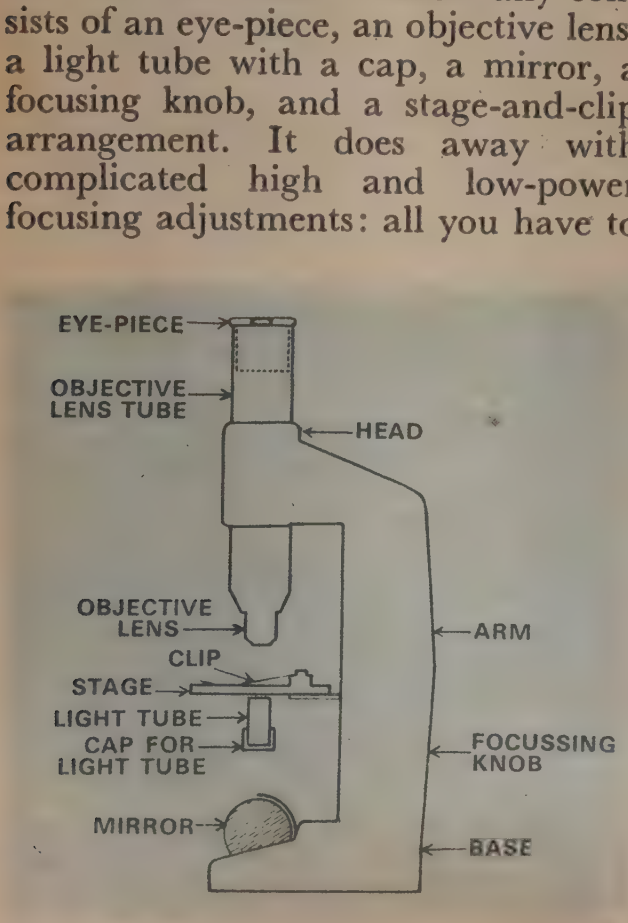
V. S. VENKATAVARADAN

Low-cost compound microscope gives high magnification



Mr. L. S. Prahlada Rao of the Vikram A. Sarabhai Community Science Centre, Ahmedabad, has done it again. A few years ago he had developed a simple microscope costing only Rs. 15. Now he has come up with a novel compound microscope that would cost just Rs. 100 — five to six times less than other microscopes of matching performance.

The new compound microscope is based on the use of spherical glass beads as in the earlier model and gives a magnification ranging between 250 and 350 times. It essentially consists of an eye-piece, an objective lens, a light tube with a cap, a mirror, a focusing knob, and a stage-and-clip arrangement. It does away with complicated high and low-power focusing adjustments: all you have to do is to change the respective tubes for low or high magnification. Stage movement is effected the same way as in sophisticated microscopes. The problem of focusing the tube and the risk of breaking the slides when the rack-and-pinion mechanism fails have been eliminated. And the use of a simple light tube with a cap to vary the light intensity obviates the need for complicated components like condensers and diaphragms.



Briefly, this is how the microscope is used. Keep it on a flat table in front of a window or any other light source. Put the low power tube in position, look through the eye-piece, and adjust the mirror to get a uniformly bright field. (If a lamp is the source of light, its distance from the mirror should be adjusted to get the correct light intensity.) Now lower the stage slightly by rotating t focusing knob clockwise and place t slide on the stage so that the specim is just above the hole on the stag Look through the eye-piece again a rotate the focusing knob gently an clockwise until a perfectly focus specimen comes in view. To see t specimen under higher magnificatio just take out the low power tub transfer the eye-piece to the hig power tube, place it in position, a adjust the knob by rotating it un the specimen is in focus.

The device combines simplicity construction and operation with hig magnification as achieved by mo expensive microscopes. It could be a ideal teaching aid for schools, eve in rural areas. It is already in co mercial production.

BADIUDDIN KHA

Mechanical drying of paddy grain

Sun drying is the conventional method for drying paddy or other grains. Besides being slow, tedious and weather-dependent, this method leads to non-uniform drying. Mechanical drying of paddy using hot air, on the other hand, facilitates the drying of a large volume of grain in a relatively short time, independent of weather conditions. It also promotes uniform drying and gives grain of superior milling quality. The Rice Process Engineering Centre of the Indian Institute of Technology, Kharagpur, has developed a mechanical drier which could be used to dry paddy and other cereals, pulses and oilseeds.

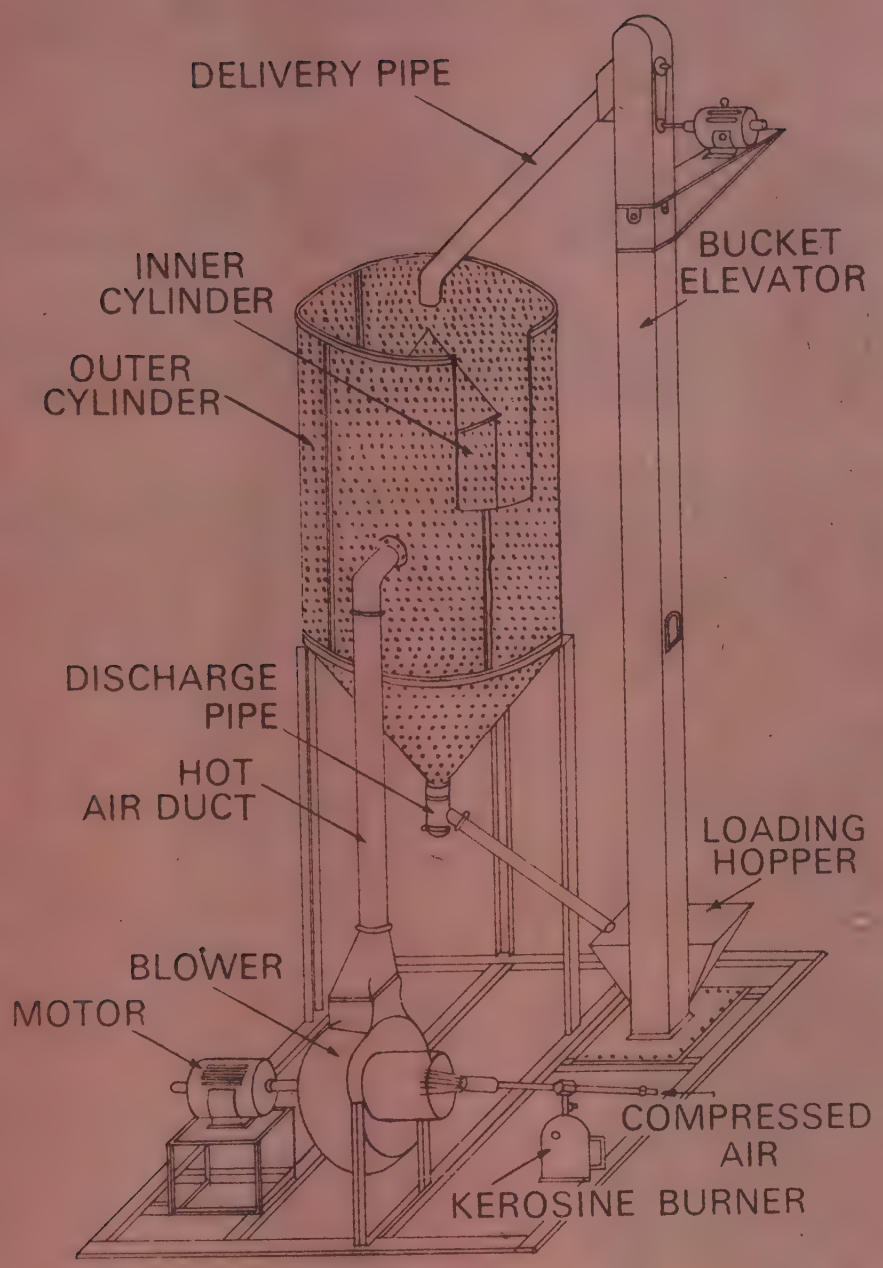
In multiple cropping, it is necessary to harvest the crop early to release the land for the next crop. In the case of paddy crops, studies have shown that the crop should be harvested when the grains attain biological maturity; the moisture content of grain at that stage is around 20 to 25 per cent, depending on the variety. Keeping the crop longer in the field may mean losses — due to shattering of grain by birds and rodents.

When crops are dried in the field, the grains often develop "sun cheeks" and also give excessive broken grains during milling. And if it is the summer paddy, harvesting coincides almost with the onset of the monsoon, when sunny days are not assured. Some varieties of paddy have a short dormancy period, and, if not dried immediately after harvest, may sta germinating because of the hig moisture content. It has been foun that the optimum moisture conte for storage is 12 to 14 per cent, d pending on the period of storag The moisture content should, ther fore, be brought down to a level sa for storage and processing. Beside the continuous processing operatio in a modern rice milling plant, wit facilities to parboil paddy, make necessary to dry paddy mechanicall

Keeping all this in view, the Ric Process Engineering Centre at IIT Kharagpur, developed the mechanic drier. It is a continuous recirculatin batch type drier with a holdin capacity of 1·25 tons.

The drier consists of two concen tric cylinders (Fig. 1) made of per forated (2 mm diameter) mild stee sheet of 20 gauge. The inner cylinde is 90 cm in diameter and 150 cm i height, while the one outside is 135 cm in diameter and 225 cm in height The former has a conical top an bottom, made of the same perforate sheet; this keeps uniform distributio of heated air. The outer cylinder als has a conical bottom with a slope o 45°. Further, the two cylinders ar placed, such that the gap betwee them is 22·5 cm. The cylinders ar supported on a frame by means of suitable foundation.

A bucket elevator, 6 metres high with a capacity of 2·5 tons per hour is installed beside the drier for load ing and for recirculating the grains A centrifugal fan (85 cubic metre pe minute air-flow rate at 5 cm o water pressure), with provision fo



eating the incoming air by a kero-ne burner, blows heated air at 0°C for raw paddy and 80°C for arboiled paddy into the inner cylin-er. Alternatively, a paddy husk-fired rnace could also be coupled with ie fan.

Paddy to be dried is fed into the evator hopper, lifted and delivered the drier from the top. The paddy omes in contact with hot air as it ows downwards in the gap between ie two cylinders. The feed rate is ontrolled by regulating the dis-harge gate provided at the bottom nd the grain is diverted to the ele-ator hopper. The paddy is recircu-ted till the moisture content drops the desired level. The grain is then nloaded, and is either stored or rocessed.

Depending on the initial moisture ontent of the grain, the drier will take wo or three hours to dry a lot of paddy 1·25 tons); sun drying will need ight to 10 hours, provided there is right sun. The total cost of the rier is estimated at about Rs. 15,000, a kerosine burner and accessories re included, and Rs. 12,000 if a usk-fired furnace is used. A husk-fired furnace would, in fact, cut the cost per ton of drying nearly by half, Rs. 10, compared to Rs. 18 when using a kerosine burner. The cost of conventional sun drying is Rs. 9 to Rs. 12 per ton (which represents the cost of land, concrete flooring, labour, losses, etc).

The drier has been tested under varying agro-climatic conditions in Tamil Nadu, Andhra Pradesh and West Bengal. The results show that it is suitable for drying raw as well as parboiled paddy. This can also be used for drying seed paddy and other cereals, pulses and oilseeds. Cost-wise, this method compares favourably with that of sun drying adopted generally by the organised sector of the rice milling industry. The mechanical drier can be used intensively at the village level by a farmer or a group of farmers to dry paddy in monsoon conditions. Six manufacturing firms have already secured rights for the commercial manufacture of the drier.

SURESH PRASAD

[Mr. Prasad is research engineer at the Rice Process Engineering Centre, Indian Institute of Technology, Kharagpur.]

Movable stadium

Lack of good playgrounds in cities is a major problem in developing sports in India, while large stadiums are often used exclusively for one game, played only during part of the year. Why not use the stadiums for various games round the year?

But different games would need different seating arrangements. A new, movable stadium in Honolulu, USA, is designed to be used for different games like tennis, soccer, baseball, boxing and even theatrical plays.

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THE SCIENCE OF THE LONG JUMP

JAL D. PARDIVALA

Some people, it is said, dream about it in their sleep — a running take-off, and then, instead of touching the ground a couple of metres ahead, the body sails along in a curving trajectory to land far ahead. How far? Six metres? Seven? Eight? Eight point nine? How long is 8·90 metres? Five men, 1·78 metres (5 ft 10 in) tall, lying on the ground head-to-toe in a line. That's quite far, isn't it? Well, that's exactly the distance Bob Beamon of the USA jumped at the Mexico Olympics in 1968. It was so fantastic that sports writers went wild looking for apt superlatives — " rendezvous with the Infinite ", " a leap to immortality ", a jump that " will well survive as a world record into the 21st century "! Some called it a " freak ". And then, some said, it was not Bob Beamon but the rarefied atmosphere of Mexico City (2,242 m above sea level) that did it!

A world record that had lasted for a long time was Jesse Owens's long jump of 8·13 m (26 ft 8·25 in) established in 1935. Thereafter, Ralph Boston of the USA and Igor Ovanesyan of the USSR, through their keen rivalry and effort of years (1960–67) brought it up to 8·35 m (27 ft 4·75 in). This was Ovanesyan's mark at Mexico — second best after Bob Beamon's. Like Beamon, Ovanesyan, too, had enjoyed the natural advantage of Mexico City's rarefied air. Which is why, Arnie Robinson's (US) same mark of 8·35 m at Montreal Olympics last year is considered to be a " better " performance as it was achieved at sea level. Bob Beamon's 8·90 m-leap has not been equalled since. After he won the gold at Montreal, Arnie Robinson was asked, " Is 29 feet possible again? " He answered, " It's possible if we can get a big invitational in *Mexico* during the peak season, with all the good guys, all the good competition! " (The high altitude factor has also been mentioned in the case of India's Yohanan's Asian record-breaking long jump of 8·07 metres in 1974 at Teheran which is 1,200 metres above sea level.)

Higher the parabola, the greater is the horizontal distance. It is, in a sense, a jump for height at the end of a sprint; and the distance achieved depends on how long the jumper can remain in the air. Now, the factors that help a jumper stay longer in the air are, (1) the speed of approach and (2) elevation at take-off. However, in his *Mechanics of Athletics*, Geoffrey Dyson points out that speed is not the ultimate factor in long jumping performances. Even an athlete capable of 2·1 m (7 ft) high jump and 10·2 sec for 100 metres would be compelled in long jumping to take off at horizontal and vertical velocities much less than might be expected. " Efficient long jumping," Dyson writes, " is, therefore, some thing of a compromise. He reaches the board at a high, but not his top, speed, giving sufficient time for a great (but not his greatest) vertical acceleration."

In other words, it is the ability to transform horizontal speed and link it with the spring that makes good long jumpers. Speed must not be sacrificed for height in the air and, conversely, too much speed does not allow sufficient elevation of the body at take-off.

Long jumpers who have reached world class have been so varied in stature and physical type that it is difficult to classify them into one group. Take the instance of four famous jumpers. Jesse Owens was of medium height, while Chuku Numbu of Japan, who had established a world record of 7·98 m (26 ft 2·25 in) in 1931, was of a very short stature. Bob Beamon is 1·91 m (6 ft 3·25 in) tall and Arnie Robinson's height is 1·88 m (6 ft 2 in).

Though some short men have become good long jumpers, the tall man has an advantage, simply because he can lift his body and legs higher in his transit across the pit and is able to

Jesse Owens was an outstanding sprinter and hurdler as well as long jumper and held the world records in the sprints, 200m hurdles and the long jump at the same time. Ralph Boston was an excellent hurdler and better-than-average high jumper. The table below gives the marks attained in 100m sprint, high jump and the long jump by five leading long jumpers of the world.

	100m (sec.)	High jump	Long jump
Jesse Owens (USA)	10·2	1·98m (6′ 6″)	8·13m (26′ 8·25″)
Igor Ovanesyan (USSR)	10·4	2·00m (6′ 6·75″)	8·35m (27′ 4·25″)
Ralph Boston (USA)	10·7	2·05m (6′ 8·75″)	8·35m (27′ 4·25″)
Bob Beamon (USA)	10·3	1·95m (6′ 4·75″)	8·90m (29′ 2·5″)
Arnie Robinson (USA)	10·2	2·08m (6′ 9·75″)	8·35m (27′ 4·25″)

Fig. 1 Jesse Owens, one of the finest exponents of the "hitch-kick" style, shown in different phases of his jump. (A) Mark his attention on the take-off board and balance of the whole body. (B) After the take-off. Note the arm balance and the knee lift of the free leg (leading) and the upright trunk [*contd. overleaf*]

C

Fig. 1 (C) Jesse Owens at the highest point in the flight. The arms and trunk move forward and, at the same time, the take-off leg (right) comes forward for the onward journey. (D) Trunk inclined forward, arms pointing straight down and legs fully extended, he is ready for the shoot and landing. (E) A perfect long jump finish.

During his career, Jesse Owens held the world records for 100 yds (9·4 sec); 220 yds (20·3 sec); 200 m (20·3 sec); 220 yds hurdles (22·6 sec); 200 m hurdles (22·6 sec) and long jump (8·13 m = 26 ft 8·25 in). At the 1936 Berlin Olympics, he had won four Olympic gold medals in 100 m, 200 m, long jump and for the 4 × 100 m relay. His Olympic long jump record (8·06 m = 26 ft 5·25 in) stood unbeaten for 24 years until Ralph Boston improved it to 8·12 metres (26 ft 7·75 in) at the 1960 Rome Olympics

D

E

reach farther with his legs and heels on landing — a very significant point when centimetres and fractions can mean a difference between winning and breaking a record or not.

A long jumper needs strong elastic muscles. He must also be a good sprinter, possessing good leg power, spring and co-ordination. However, even long jumpers without outstanding sprinting skill may become top performers as long as they perfect the technique in all its details.

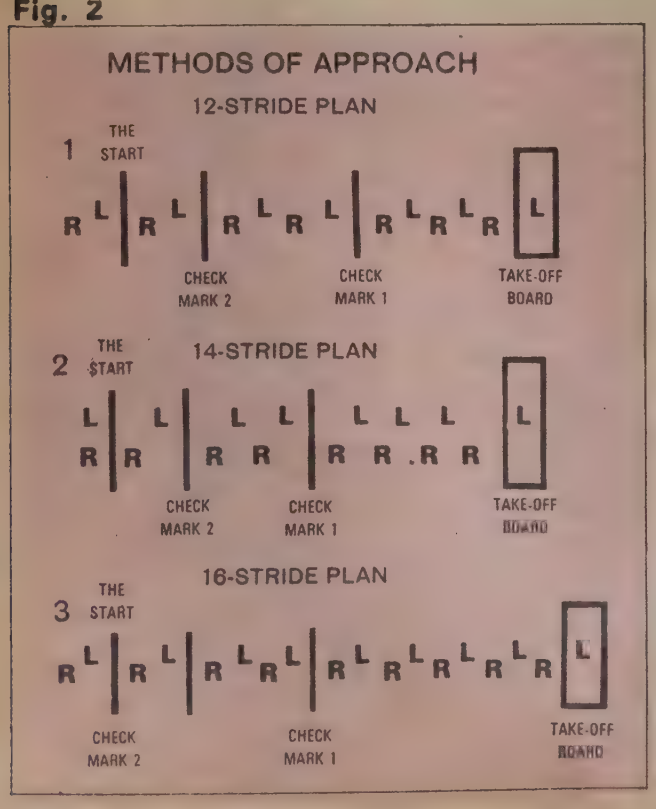
THE APPROACH: An athlete who can generate a burst of controlled speed from 30 to 50 metres away is at an advantage; he will be able to hit the board correctly and without losing his optimum speed. Since so much of the approach run, the jumper must be able to reach the take-off board with his *correct take-off foot*, and at the same time he must be in a position to evolve further movements without losing his body balance.

10 9 8 7 6

Fig. 3 THE PERFECT TECHNIQUE: Picture series of Heide Rosendahl (W. Germany), world record-holder (6·84 m = 22 ft 5·25 in) and 1972 Munich gold medallist (also silver medallist in women's pentathlon). (1 & 2) The jumper is gathering and driving herself into the board for a spring. (3) The take-off foot (right) has come to the board in advance of the body, partly flexed, head and chest held well up. (4) The body kept well up is passing over the take-off foot with a heel-ball-toe action. (5 & 6) Take-off leg is extended properly and the leading leg knee (left) is lifted up well towards gaining height. (Co-ordination of arm and leg action is to be noted — left leg-right hand and vice versa.) (7–11) Body kept well erect in the air, she is taking 1½ strides (run-in-the-air or hitch kick). (12) With good balance of the body and leg extended forward and driven farther, the arms travel behind the jumper for good balance. (13 & 14) A very good landing position is carried out with feet well up and forward; heels ready to break the jumping pit which is done in 14. (15) Note how the arms are in motion to come forward and upward over the knees which are flexed; the body is in the act of moving forward over the feet

Technique in long jump has one aim: to convert forward momentum into vertical height off the board. There are four components of the jump to be considered: (1) the approach, (2) take-off, (3) action in the air, and (4) landing.

Fig. 2



depends on the approach run, care should be taken in determining the proper length of the run and the method of hitting the take-off board. The length of the run will vary according to the jumper. The slower, shorter-striding, small individual will take fewer strides than the faster, taller, longer-striding athlete. The important point is, the jumper *must not be fagged out* when he reaches the take-off board.

What's more, whatever the distance

Uniform strides must be developed to get a satisfactory take-off. The run should be gradually accelerated, and top, but controlled, speed should be reached before the jumper comes to the take-off board. It is advisable to 'coast' the last 2/3 strides so that the jumper can gather himself for the spring. During these strides, the trunk should be brought upright, and the hips slightly lowered to enable the powerful muscles (extensors) of the legs to be in a good position for a

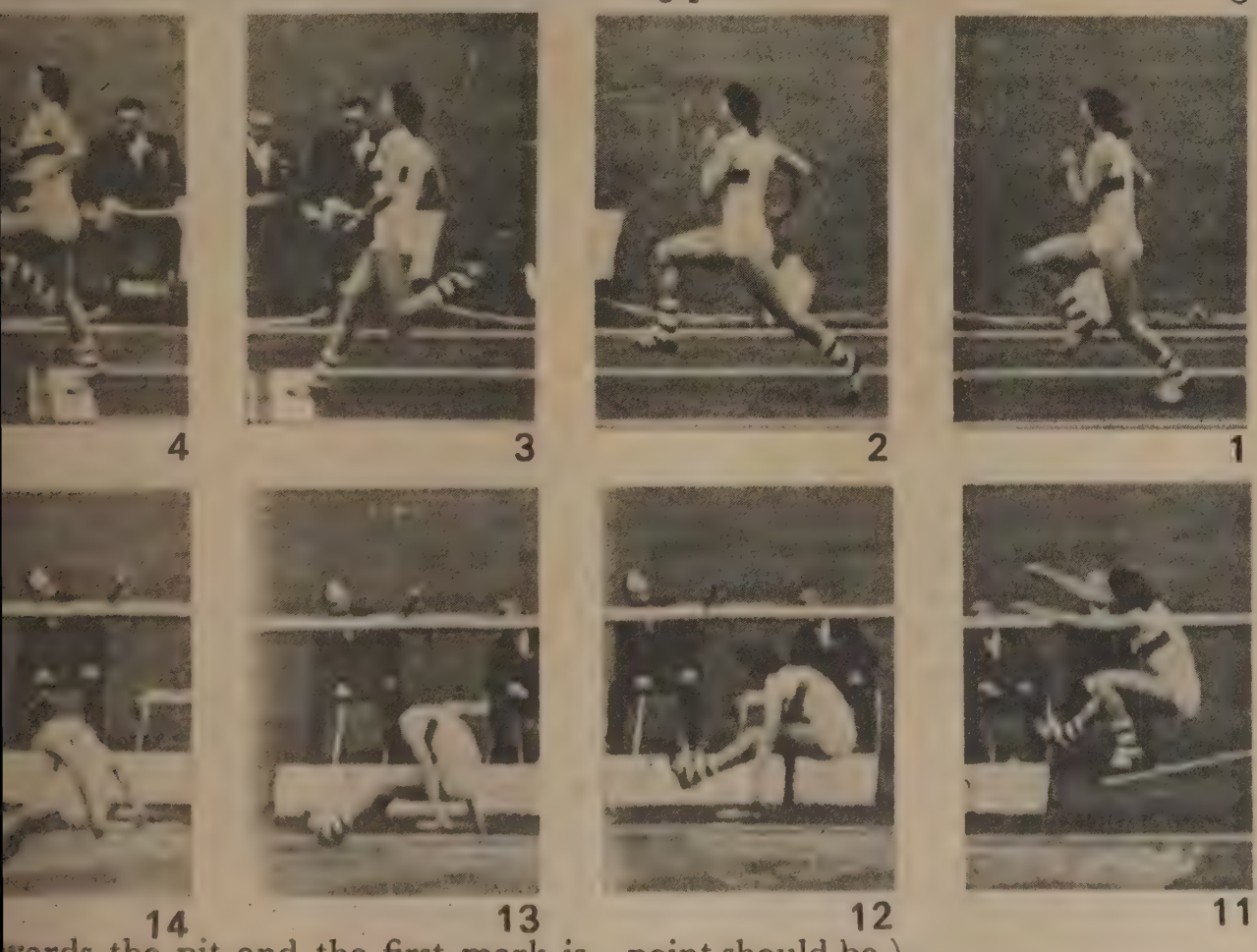
orous and explosive take-off.

Study the three approach stride ns (Fig. 2); remember these are y given as a guide. Those who her the right momentum after a g approach run will have to use third plan of 16 strides or more. ose who gather momentum at a dium speed should choose the ond plan. The 12-stride plan is for se who gather speed in a short tance.

It must be pointed out here that at ntreal, many athletes used 18 to 23 ides (which included their initial lk or jog in). This is due mainly to enormous improvements shown present-day sprinters-turned-long npers. Nowadays, even a 10·2 or ·3 sec (for 100m) sprinter knows at he has little chance of reaching top in that event and thus con-ntrates on long jump and suc-eds. Arnie Robinson is a standing ample.

Whatever the stride plan chosen, it good to put three check marks for correct take-off. In all three plans, start is at the third check mark; second check mark is two strides

Fig. 4 "Rendezvous with the Infinite" — Bob Beamon at the 1968 Mexico Olympic Games where he leaped to 8·90 m. After gaining the highest point in the parabola, he has brought the legs round the side and the arms are between the legs in mid-flight, which is unethical. Beamon with his amazing speed (10·3 sec for 100 m) and good high jump quality (1·95 m = 6 ft 4·75 in) had taken full advantage of Mexico's high altitude. He threw to the winds the accepted technique of long jumping and after reaching the highest point, turned himself almost into a ball, thus reducing the air pressure on his body. Mexico is at an elevation of 2,242 m (7,440 ft) where air is approximately 23 per cent thinner than at sea level. Thus, the consequent reduction in the air resistance is favourable to sprinters and jumpers



wards the pit and the first mark is r strides away from the second ark towards the pit. These check arks need careful adjustment ac-rding to the jumper's strides. A rtner can assist the jumper in plac-g the check marks correctly and in astering the run-up to the take-off ard. An ideal way to adjust the rting point is to choose any arbit-ry point 25 to 40 m away (depend-g on the speed) from the board. n down and jump naturally, *oring the take-off board.* Do this several nes. If the take-off foot mark is be-nd the board, shift the starting mark ther away. If it is a few centimetres short of the board, then shift the start-ing mark closer towards the pit. Prac-tise several times to get the correct position. (Remember, it is not proper to *run back* from the board to the start-ing point to decide where the starting point should be.)

After you have fixed a reliable starting point, choose a point two strides from the starting point; this must be hit every time with the take-off foot. When this mark is correctly determined, check another mark six strides from the starting point and four strides from the second mark; this becomes the first check mark. After the check marks are thus chosen, the athlete must remember their dis-tances from the take-off board. These marks should be reached by the take-off leg even during practices. When the rhythm of the run has been per-fected, either the first or the second mark can be disregarded (in order to avoid the distraction of intermediate marks and, thus, to allow complete concentration on the run and the jump). *Never change the stride to hit the board.*

It must be noted that the running surface condition and wind velocity will cause changes in check marks to a certain extent. However, once the steps have been accurately deter-mined, there need not be any diffi-culty.

TAKE-OFF: One of the most com-mon faults, especially among begin-ners, is *looking down at the take-off board while taking off.* It is extremely im-portant that the habit is not acquired, for it destroys the mental concentra-tion.

The take-off foot should come to the board ahead of the body, with the take-off leg partly flexed and head and chest held well up. As the body passes over the take-off foot, the leg should extend powerfully, and the foot should complete a heel-ball-toe action. The

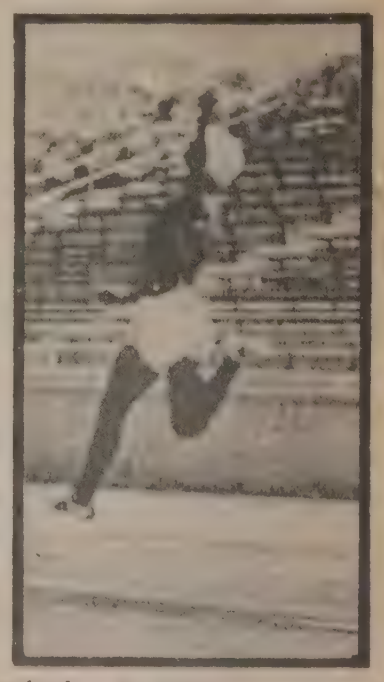


Fig. 5 Ralph Boston, 1960 Rome Olympic champion and one-time world record holder (8·35 m), demonstrates an exercise he had devised to help increase the height of his jumps—touching his head to a towel suspended high over the pit, thus forcing his body to follow a higher arc in the air ("higher the parabola, greater the distance")

(Right) Gregory Bell of USA trying to reach the highest point of the parabola with arms fully stretched skyward at the 1956 Melbourne Olympics where he won the gold

Fig. 6 "ACTION IN THE AIR" TECHNIQUES. (Above) Stan Richardson of Canada with knees well up at the top of his flight in the "sail" style

(Below) Michel Gourdine of USA takes a stride in the air at the 1952 Helsinki Olympics where he won the silver. Note the co-ordination of left leg and right arm

(Above) Dr. Steinbach, one of W. Germany's most successful athletes, displays "sit-in-the-air" action

jumper, when he drives himself into the air, has his body directly over the take-off foot and all effort in this part of the action should be directed towards gaining height. There should be no backward lean, as this reduces the momentum and makes the forward hip swing difficult.

The jumper must not be in a hurry to leave the board. He should give time to his take-off (jumping) leg to complete the spring and the free leg should have time to complete its upward swing. Proper co-ordination of the drive of the take-off leg, the forward swing of the free leg and the upward and forward swing of the arms is essential for a good take-off.

At the instance of leaving the board, the body should be erect from head to toe, with the centre of gravity slightly ahead of the take-off foot. From the time the rock-up action of the take-off foot starts, the athlete must concentrate his efforts, driving his chin and eyes as high as possible into the air. Finally, to make the speed of his approach run effective, he must be able to leave the board with perfect balance so that he does not lose height during the progress of his flight.

Remember, take-off is the most critical phase of a long jump. Once the body has left the ground, there is nothing a jumper can do to change the "flight characteristics" of his centre of gravity".

ACTION IN THE AIR: Once in the air, the aim is to remain in flight for as long as possible and to maintain balance. There are three ways of doing this: (*i*) Sit-in-the-air or "sail" — this is the old style. After leaving the take-off board, the arms are carried upwards and forward to their maximum height and then the knees are tucked up to the chest. The jumper holds the stance and sails as far as his momentum carries him. The lower limbs are then swung forward to increase the length of the jump. The arms are swung back to keep balance, however, as soon as the heels touch the ground, they are swung forward vigorously to avoid falling back into the pit.

This is the easiest of the three methods, but is not effective as far as maximum distance is concerned.

(*ii*) Hitch kick or run-in-the-air: Most coaches agree that this is the best

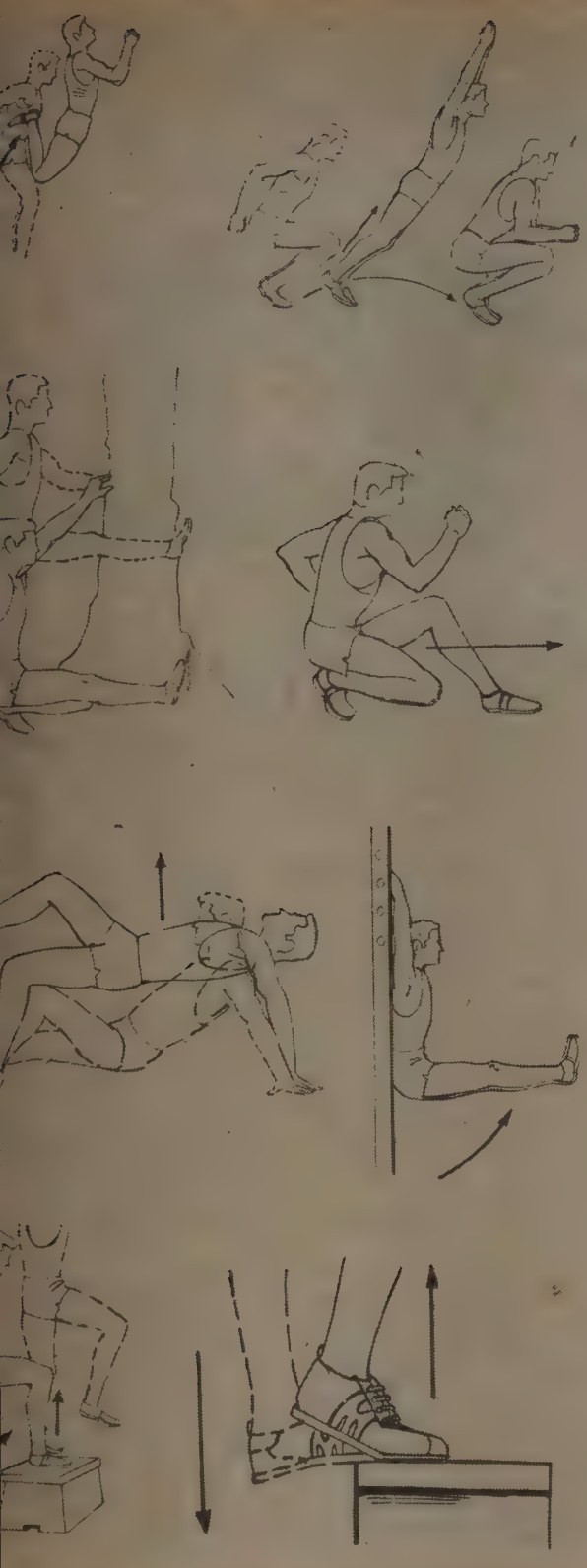
TRAINING

Long jump should be undertaken after six weeks of general body-conditioning exercises, such as heel and toe lifting, hopping off the take-off foot, jogging, striding, bending and stretching exercises and all types of leg strengthening exercises (see diagrams).

Jumping for form should be combined with starting practices and other dash work with sprinters. Practise foot rolling action (heel-ball-toe) till this becomes mechanical. To get sufficient amount of leg and arm co-ordination, a good work out on the gym spring-board during off season will help a lot. Quick knee dips with bar-bell over the shoulders should also form a part of the training. To develop rhythm in the strides, run over 3 or 4 low hurdles (0·76 m = 2′ 6″) arranged at the usual 110 m distance (100 m or 80 m for women).

It is suggested that jumpers spend more time on small but sharp practice jumps using a fast 15 to 20 m run. These are called ' pop-ups '. This running on the board action, when done many times with short, non-fatiguing runs, becomes mechanical and is executed perfectly when a full run is used in competition. This way the jumper can jump many more times and there is less likelihood of excessive fatigue.

During training, the aim should be to hold the form and try and increase strength and speed; therefore, do plenty of speed work-outs. Also, occasional jogging over 800 m is good, but this must not be overdone, or the jumper will lose his bounce.



Here is a simple work-out:

Early season: Plenty of running and perfecting the approach runs. Plenty of pop-ups. Very little jumping for distance.

Mid-season: Increase the work-load, perfecting technique. The main workout should be with sprinters or hurdlers. Continue with pop-ups. Jump for distance once a week.

Now, the weekly pattern:

Monday: Start by jogging a lap. Spend 10 to 15 minutes on body-building, bending and stretching exercises, hopping, etc. Work with sprinters, running short sprints of 30 to 50 metres. Practise a few pop-ups. End by jogging a lap.

Tuesday: Spend 15 to 20 minutes on loosening up and warm-up work. Alternate jogging and sprinting with a few practice starts. Perfect the run-up by running through the approach 3–4 times. Six to eight pop-ups with emphasis on height and form. After rest, run over 3–4 low hurdles 3–4 times to develop rhythm in strides.

Wednesday: Easy work with the sprinters. Practise relay baton changing for developing alertness.

Thursday: Usual warm-up, stretching and bending exercises. Short sprints. Run through approach 3–4 times. Practise for form in the air. Finish up by striding an easy lap.

Friday: Rest.

Saturday: If no competition, six jumps for distance at full effort. Keep careful note of each jump. If you note an improvement, try to figure out how and why.

d-air movement, and when per-ted, enables the athlete to land h his feet slightly ahead of the ht path of his centre of gravity.

In this style, as soon as the body d arms are carried forward and ward with a swing, the jumper ecutes a running motion with his ding leg; then he brings up his e-off leg for a second stride, com-ting his running action at the high-point of his flight with a forward ng of the hips. The 'run-in-the-' should begin at the take-off. If left foot is the take-off foot, the ht leg naturally follows through h a high knee-lift (which is very ilar to the *stride over the hurdle*). The is then thrust out and back, the t carried up behind. The take-off (left) is then brought forward in a

Fig. 7

stride just as if the jumper were running on the ground. The opposite or lifting leg (leading) follows through in the normal way. During the flight, the arms work in conjunction with the legs.

The advantage of this style is that the body remains erect during the early phase of the flight. This makes it easier to get the forward hip swing at the top of the flight, which ultimately helps in throwing the legs forward for landing.

(*iii*) The hang: In this the athlete reaches his maximum height with the chin and chest up, the back arched and the lower limbs trailing behind the rest of the body. The arms are thrown up to maintain balance. As the jumper reaches the highest point of his flight, the hips are swung forward. As they go forward, the legs are extended and the jumper tries to bring his feet up almost level with the hips (see Fig. 7).

LANDING: A good landing can add centimetres to the jump. Landing efficiency is increased if immediately before touching the ground, the arms are behind the jumper; this also helps in body balance. The arms are driven forward just at the landing to assist in rock over the heels. The aim is to first touch the ground with the legs extended forward with a good balance of the body, then to bend just after the moment of contact with the pit, and finally fall forward. The feet are 30 cm or so apart so that the body may go between the knees and over the feet when the pit is touched.

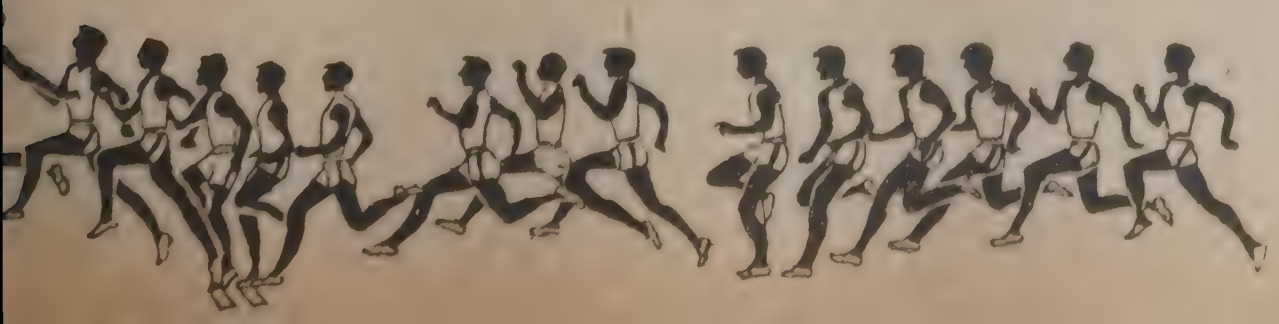
While landing, the jumper should not dip his trunk too far forward, otherwise the advantage gained from a good forward thrust will be lost. The jumper must try and relax at the knees, allowing the body to fall forward over the feet.

ARNIE ROBINSON'S TRAINING

Arnie begins each work-out with a mile jog; he does no specific warm-down. Various training venues are used, including hills, stairs, tracks and weight-rooms. Arnie also does high jumps for leg spring. Training remains relatively constant the year round, with four track sessions per week. Competing throughout the year, Arnie also enters events other than his speciality during the off months. His best marks include 9·5 sec for 100 yds, 21·4 sec for 220 yds, 2·08 m (6′ 9·75″) in high jump and 15·54 m (51′) in triple jump.

A sample of his work-out week during March:
Monday: 3 × 330 yds (38 to 39 sec); and hurdling.
Tuesday: 1 × 100 yds; 2 × 75 yds through pit; 3 × 60 yds; 4 × 50 yds; 5 × 35 yds; 6 × 25 yds; weight training consisting of half-squats and light upper body work.
Wednesday: Same as Monday.
Thursday: Same as Tuesday.
Friday: Rest.
Saturday: Competition.
Sunday: Stairs or hills (numbers vary).

(From *Track Technique*)



learn while you play—6

B. D. KELKAR
A. V. DESHINGKAR

We begin our adventure this month into the fun-and-games world of science with a famous work from the world of art. Shown above is a beautiful painting called "Soap Bubbles" by the 19th century French painter Edouard Manet. Painted in 1867, "Soap Bubbles" was one of Manet's revolutionary paintings (we cannot show you its colours, though): unlike painters of his time, Manet had turned his back on grand and beautiful subjects and painted only what appealed to his senses directly. Maybe, someday, you will get to know more about Edouard Manet's style. Let's go on to the subject: soap bubbles.

What is the scientific explanation of soap bubbles? For an answer, we have to know something about the behaviour of fluids.

Let's begin with fluid pressure. Remember, fluids include both liquids and gases. That fluids exert pressure is well known. As the water level in the kitchen tank falls, water comes out of the tap at a very slow rate. Go up in a plane or up a mountain, and you get that funny feeling in the diaphragm of your ears. Actually, we are rarely conscious of the fact that we live submerged in a great sea of air called the atmosphere. How do we measure this air pressure?

The problem had puzzled Galileo. Diggers of wells were aware of the curious fact that the pump couldn't raise the water more than 9·73 m (32 ft) above the level of the water in the well. Why not? Galileo found the answer in 1640 (a few years earlier, he had proved that air has weight!): when the plunger in the tube was drawn up, a vacuum was created in the tube; Galileo reasoned, the weight of air pressing down on the surface of the well was just heavy enough to push the water up the pump tube to a height of 9·73 m.

Galileo died in 1642. In 1643, his pupil Evangelista Torricelli, found a way of measuring the pressure of air. He argued, if the pressure of air pushed water to a height of 9·73 m, then the same air pressure should push a column of mercury 1/13th as high (since mercury is about 13 times as dense as water) — that is, up to 74·9 cm (29·5 in). Torricelli made a glass tube with one end closed. He then filled it with mercury, and placed it upright with the open end in a basin filled with mercury. The column of mercury in the taller, closed end of the tube fell until it was between 74·9 and 76·2 cm (29·5—30 in) high. This level of mercury rose or fell according to the changes in the air pressure due to changes in the weather — that is, as solar heat, changes in the direction and strength of air currents, etc caused changes in the density of the atmosphere. This is the secret of the barometer (Fig. 1).

Fig. 1

The actual measurement of air pressure was done, however, by Torricelli's contemporary, Blaise Pascal. Pascal first weighed the mercury needed to fill a tube 30 inches long and one inch in area across; this was about 15 lb (6·8 kg). Pascal calculated that the weight of a column of air standing on a base of the same size and reaching to the top of the atmosphere was the same as the weight of the column of mercury it balanced, that is, 15 lb at sea level.

Indeed, how great this air pressure is was demonstrated in 1654 by Otto von Guericke — this was the famous "Magdeburg hemispheres" experiment. Two copper hemispheres of about 55 cm diameter were joined and

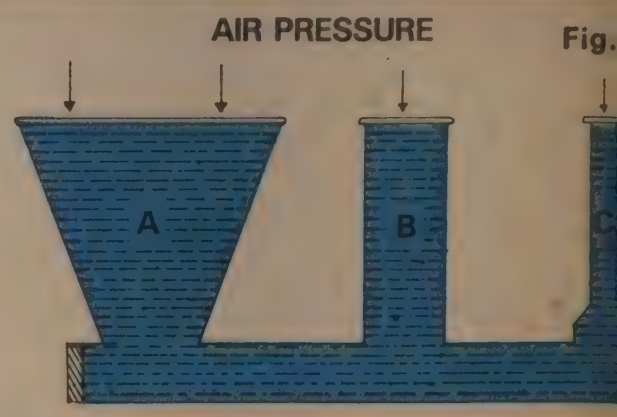


Fig.

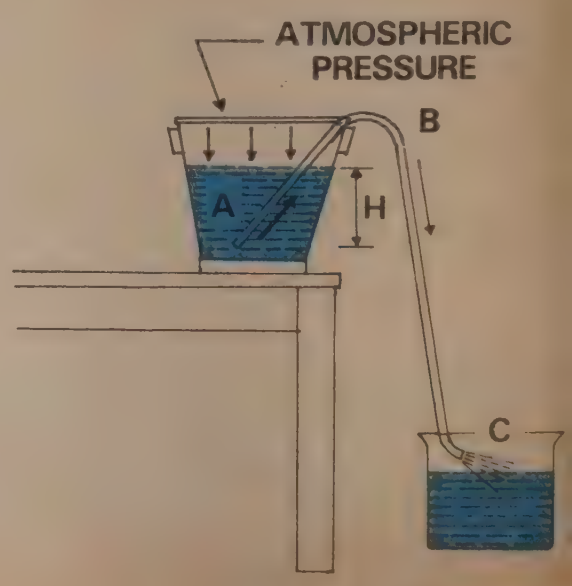
the joint was made airtight. After th air inside the sphere was evacuate two eight-horse teams couldn't pu the two halves apart. To separa them, a force equal to the product the sphere's area and the pressure atmospheric air would be needed.

Like air, liquids, too, create pre sure due to their own weight. Yo must have studied in your text-boo that this pressure depends on th depth and density of the liquid. Bu then, if the depth remains the sam does the shape of the containe have any effect on the liquid pressure Fig. 2 shows a horizontal (2·5 c diameter) polythene tube closed a both ends to which a plastic funne top, a tube and a bottle-top a attached tightly. When water poured into these three vessels, th level remains the same in each. Why There is more water in A than in and C. Why then isn't the liquid fro A forced into B or C? Can you wor it out yourself?

Siphons

How often hav you seen truck drivers place a rubbe tube inside a petrol jerry can, suck a the other end and pour out the petro into another container? You too ca try it out, as shown in Fig. 3. Place bucketful of water on a stool, insert plastic (transparent, so that you ca watch the water flow) tube into it an suck at the other end. When wate starts flowing out, lower this end int a can on the floor. How does the wate

Fig.

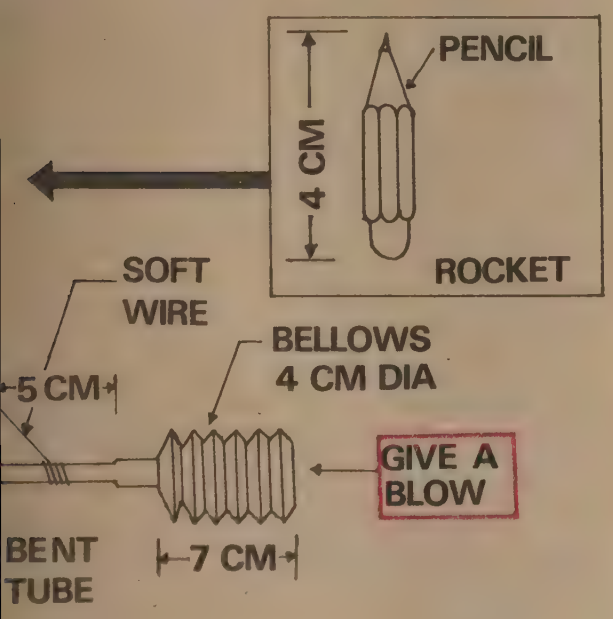


w *up* bend B before flowing down e gradient BC? The answer lies in mospheric pressure as well as the ight of the water (H) in the upper ucket. As you suck the air out of the ngth BC of the tube, the pressure of r in that part falls and the higher r pressure at A forces the liquid up e side AB — as long as the water vel stays *above* A, after which air will sucked into the tube and the flow ll stop.

This phenomenon — known as phon action — is made use of by rmers to carry water from an open tch or canal at a higher level in lds. Shown here are two interest-g toys you can make that work on e siphon principle (Figs. 4 & 5).

ydraulic pressure

Perhaps, the sim-lest way to understand this is to ake a toy first. We need only a olythene tube, bellows (from a erosine hand pump, or a rubber ulb will do) and a small pencil stub. ip the tube in hot water for a while nd then bend it at A (Fig. 6); use

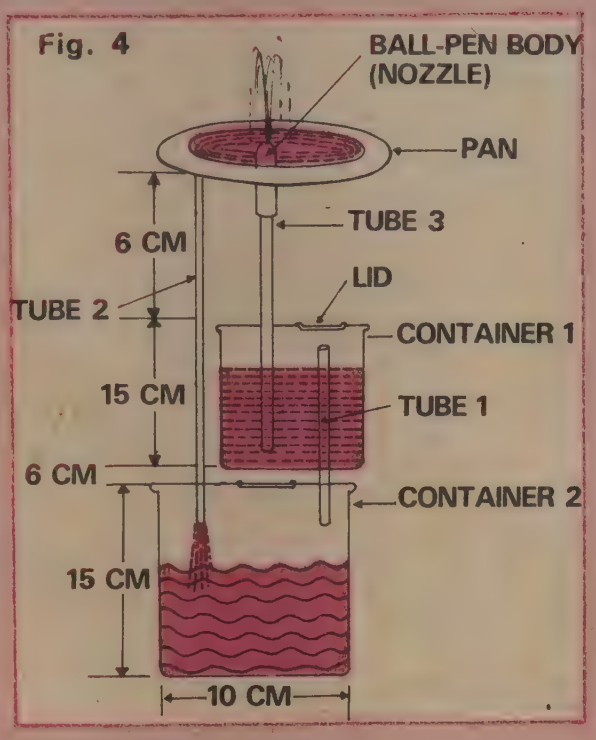


ig. 6

oft wire to hold the bend. Fill the ube with water and place the pencil tub (rocket) at the end. Give a blow n the bellows. What happens? The encil rocket flies out. The working rinciple here is the property of any iquid to exert pressure in all direc-ions. This, too, was discovered by Pascal and is known as Pascal's Law f fluid pressure. When the bellows re pressed, the pressure exerted by he water is increased and is trans-erred to the rocket end. An upward hrust equal to the pressure of liquid nultiplied by the area of rocket pencil) base acts on the rocket and aunches it.

This hydraulic pressure principle s used in a variety of applications, or example, in vehicle brakes, or in ydraulic presses used for compacting oose material, or for pressing sheet netal into different shapes.

Fountain



We need two plastic containers with lids, one shallow dish or tray, a polythene tube about one metre long, a thrown-away ball-pen body, and Araldite. Cut the tube into three pieces — Nos. 1, 2 and 3, 22, 27 and 22 cm, respectively — and pass through holes on top and bottom of the containers as required. Study the drawing for the positions of the containers as well as their connections with the three tubes. Fix the ball-pen body on top of tube 3 with Araldite to make it airtight.

Open the lid of container 1 and pour water into it such that the level remains *below* the top of tube 1. Close the lid.

Now pour water slowly in the tray till the fountain starts. You *need not* add water to keep the fountain playing. The show will cease when container 1 gets emptied. To get the fountain playing again, remove the water from container 2 and add it to container 1 and then, after closing the lids, pour water on the tray till the fountain starts functioning.

How does the fountain work? When we pour water into the tray, it flows to container 2 through tube 2 and displaces air from it. Air then rushes to container 1 through pipe 1 and increases the air pressure on the water inside. Air pressure above the open end of pipe 3 is atmospheric and hence water in container 1 rushes through the nozzle and the fountain starts playing. This continues because the fountain water is collected in the tray and is continuously supplied to container 2.

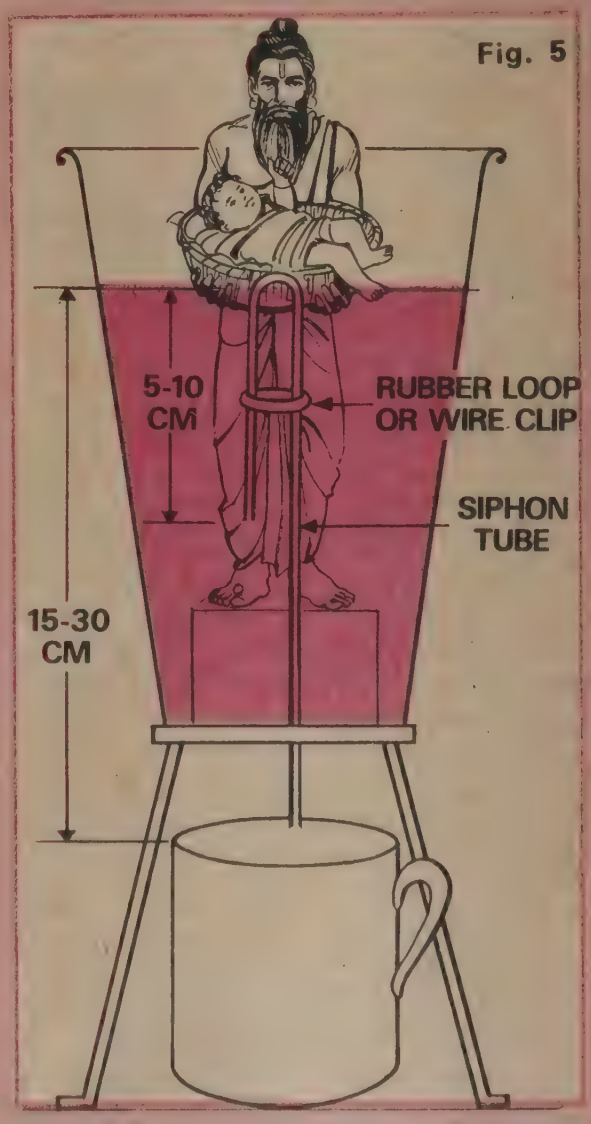
Vasudeo and baby Krishna

Remember the story of the birth of Krishna? The night he was born, his father Vasudeo took him away to Gokul to save him from Kamsa. On the way, he had to cross river Yamuna. The river was in flood and rising. But as soon as the water touched Krishna's feet, it subsided and Vasudeo could safely wade through to the other bank. How about making a toy to tell the story to your friends?

Take a polythene tube of 6 to 8 mm diameter and prepare a siphon as shown. Use soft wire to hold the bend. Prepare the outline of Vasudeo with baby Krishna from card paper, ink or colour it and cover the card with hair oil. Then fix the card on the siphon such that the top of the siphon is aligned with the baby's feet.

Now take a plastic container, make a hole at its base, pass the tube through and seal the joint with Araldite.

Pour water slowly into the container. As the level of water rises to touch the baby's feet, the siphon starts operating and water flows out as if river Yamuna gave way to Vasudeo.



Buoyancy

Ah, buoyancy! That's Eureka country. Third century BC, Syracuse (in Sicily). The king suspected the goldsmith had added some cheaper, lighter alloy to the crown he had ordered and asked his royal mathematician if he could prove it. Archimedes worried about it (in those days, chemical analysis wasn't developed). One day, as he lowered himself into the bath, he watched the water rise up the sides. It meant his body had displaced some water and the amount of water displaced was an index of the volume of that part of his body that was submerged. If he were to immerse the crown in a vessel of water filled to the brim, some water would pour out. Now, if he were to immerse in a vessel of the same size a mass of pure gold weighing the same as the crown,

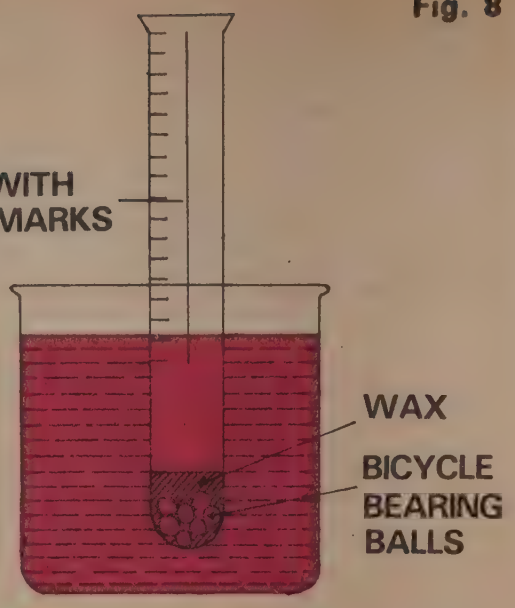
READERS

it should displace the same amount of water as before — if the crown was of pure gold.

Archimedes is said to have run straight out of the bath through the streets of Syracuse without any clothes, shouting "Eureka! Eureka!" ("I have found it!"). Thus was born the principle of buoyancy known as Archimedes's principle: "That a body immersed in fluid loses as much weight as the volume of fluid it displaces".

The proof of this weight loss is there in our everyday life. When we get into water, don't we feel lighter? Or, dip your arm up to the elbow in a tub of water and raise it slowly — you will feel it gets heavier as it comes out of the water. There's a legend in India about a wise minister of a king. The king wished to know the weight of his elephant but nobody knew of a scale that large. The minister took the elephant to the riverside, placed it on a boat and marked the water level on the boat's side. Then he asked the elephant to be taken out of the boat and the boat was loaded with bricks, until it sank to the mark made earlier.

Fig. 8



The bricks were all of equal weight; the weight of a brick multiplied by the number of bricks on the boat gave the elephant's weight.

You can make an interesting toy — the toy diver — using the principle of buoyancy (Fig. 7).

The principle of buoyancy is used in hydrometers to measure the specific gravity of liquids. Why don't we make a simple one? We need a glass test-tube and some steel bicycle bearing balls placed at the bottom — in wax preferably, so that the balls don't roll out (Fig. 8). Place the tube in wate and mark the level on the pape pasted on it. Put some salt in the wate and again mark the level. Place it i milk and make another mark. Th depth to which a hydrometer wil float in a liquid depends on th specific gravity of the liquid. In ever case, the hydrometer will sink to tha level which will cause it to displace a amount of liquid whose weight i equal to the instrument's weight. I other words, the greater the specifi gravity, the higher the hydromete will float.

Toy diver

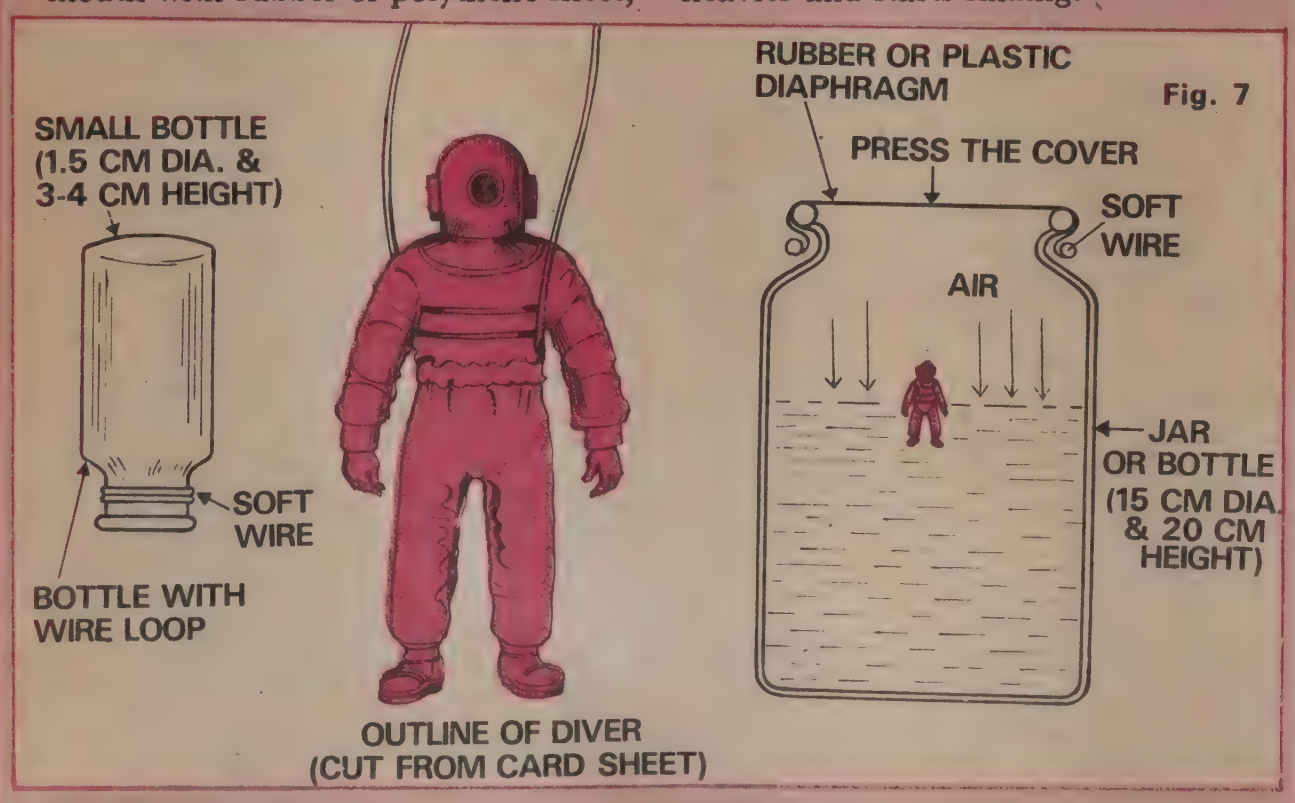
This 'buoyancy' toy is extremely simple to make. Get a jar of about 15 cm diameter and 20 cm height and one small bottle (say, an injection or capsule bottle) of 1·5 cm diameter and 3 to 4 cm in height.

Take the small bottle and wind some soft wire round its neck such that it will float in water with its mouth downwards. Fill three-fourths of the jar with water and leave the small bottle in the jar. If you wish to be realistic, cut out the outline of a diver from card paper and cover it with hair oil (to make it water-resistant); fix the figure on the bottle, maybe by a tight rubber band. Now cover the jar's mouth with rubber or polythene sheet, tied around with thread to make it airtight.

Now the toy diver is ready to dive. Press the cover with your hand and you will find the diver slowly sinks into the water; when you lift your hand, the diver rises and floats again. You may have to make some adjustments. Before you cover the jar, see that the 'diver' bottle just *floats*. You can fill the small bottle with some water initially to adjust its weight.

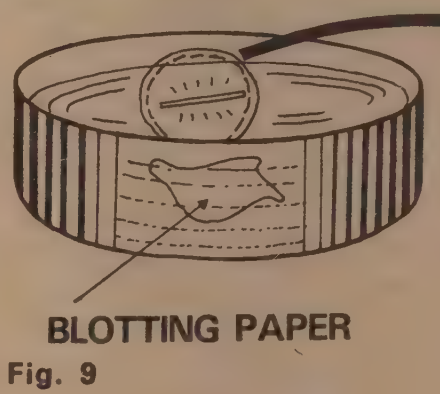
How does the toy work? When you press the cover, air in the jar gets compressed, thus increasing its pressure on the water in the jar and a small quantity of water enters the small bottle which then becomes slightly heavier and starts sinking.

Fig. 7



Surface tension

Fig. 9

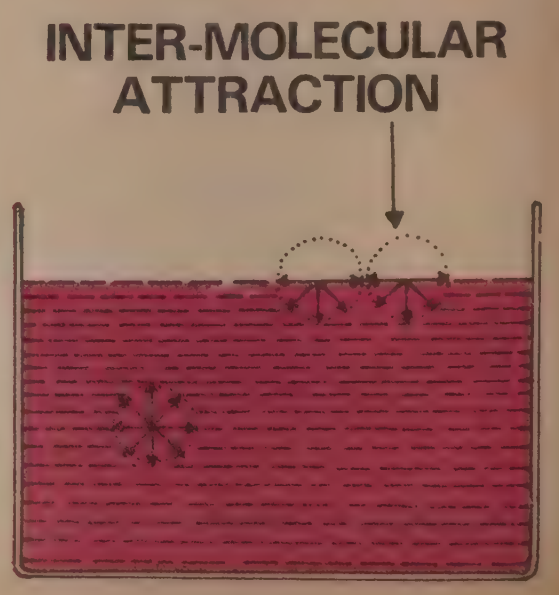


Take a small dish of water. Get a needle and cover it with grease or oil. Now place the needle on a small piece of blotting paper and gently lower them into the dish and let them float on the surface (Fig. 9). Now watch what happens.

As the blotting paper gets soaked with water, it will sink, but the needle will float. How?

The answer lies in surface tension. To understand it better, think of any liquid as made up of enormous number of separate molecules. There are various forces of attraction between these molecules. The molecules below the surface are drawn to one another in all directions, but for the molecules at the surface, the attraction is only sideways and inwards (Fig. 10). As a result, the molecules at the surface are always pulled together such that the surface acts as an elastic membrane. It is this elastic membrane that keeps the needle floating on the surface.

Fig. 10



Soap-driven boat

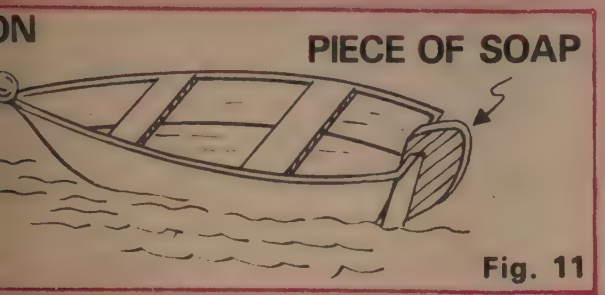


Fig. 11

Take a small toy boat and attach a bit of soap to its rear. Place it in a small tub. As the soap gets into solution, the surface tension behind the boat gets weakened and the surface tension and adhesion in the front of the boat pull the boat forward. As soon as the soap film covers the whole of the water surface, the boat stops. Be careful that no oil is present on the water surface. If you notice any oil, remove it by placing a piece of newspaper initially.

Magic fish pond

Take a thin but tough plastic sheet and cut fish shapes from it. Fasten a small quantity of good quality camphor at the notches. Place the fish gently in a tub of water and you will find the fish swimming on their own. It is almost like magic. You have guessed the reason, haven't you? The fish get energised because of the weakening of the surface tension with camphor.

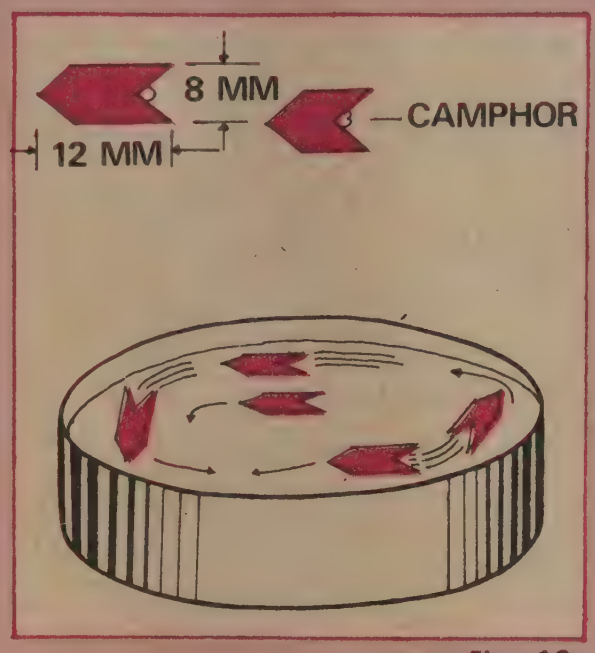


Fig. 12

The surface tension of water is greatly weakened if soap or camphor is dissolved in it. And that helps us make two fun-filled toys — the soap-driven boat (Fig. 11) and the magic fish pond (Fig. 12).

Playing with soap bubbles

So we come now to the subject of Edouard Manet's painting. There would be very few amongst us who haven't played with soap bubbles. Have you ever wondered what gives rise to them? Well, it has something to do with the surface tension property of liquids we just talked about. We have said that the intermolecular attraction of the surface molecules acts only sideways and downwards; this pull makes the surface tend to shrink to the smallest possible area — that's the way an elastic membrane is expected to behave, isn't it? — and the shape that encloses the largest volume in the smallest possible surface is the *sphere*. This is why soap bubbles (also water-drops in mists and clouds, or the bubbles in soda water) are spherical.

You can have hours of fun with soap solutions as these games shown here are ample proof (Figs. 13 through 15). However, remember, the richer the soap solution, the better the bubbles.

Bubbles are blown with warm air from the lungs, so the bubbles enclose air that is lighter than the atmosphere and hence float in the air. Did you know the soap film is so thin that the filaments of a spider's web would be 200 times thicker? The reason the bubble is formed is that the soap film provides considerable amount of intermolecular attraction which allows the bubble to stay intact for some time before bursting. And bubbles burst because they lose the moisture which is their reason for existence in the first place. If you add glycerine, it might prolong the bubble's life. Such bubbles can be rolled on the floor or on the carpet.

While you play with soap bubbles, don't forget that physicists 'play' with them, too — to study the behaviour of membranes, fibre strength, laws of cohesion, etc.

Last month we had posed two problems: (1) Why does a truck driver move the steering wheel even on a straight road? The answer is, even very straight roads have dips and crests and as the wheels move over them, a gyroscopic couple comes into the picture which tries to change the course of the vehicle either to the right or the left. The driver has to move the steering wheel to compensate for these couples. (2) Why are curving roads given a bank? The reason: the bank helps to create a balancing or restoring couple to counter the effect of the gyroscopic couple and couple due to centrifugal force trying to topple the vehicle away from the centre of curvature.

Soap bubbles

Blowing pretty large soap bubbles is a skill. To get a good soap solution, dissolve ordinary laundry soap in cold water (toilet soaps don't give good results). You must get a thick lather. Add one part of glycerine to three parts of lather to prolong the life of the bubbles. Stir the solution. Skim the froth and fly small bubbles off with a spoon.

Take a glass pipe about 10 cm long with a small hole. Apply a little soap at one end to make a smooth end and dip this side in the soap solution. Remove the pipe and holding the other end to the lips, blow air gently through. A bubble will appear.

Fig. 13

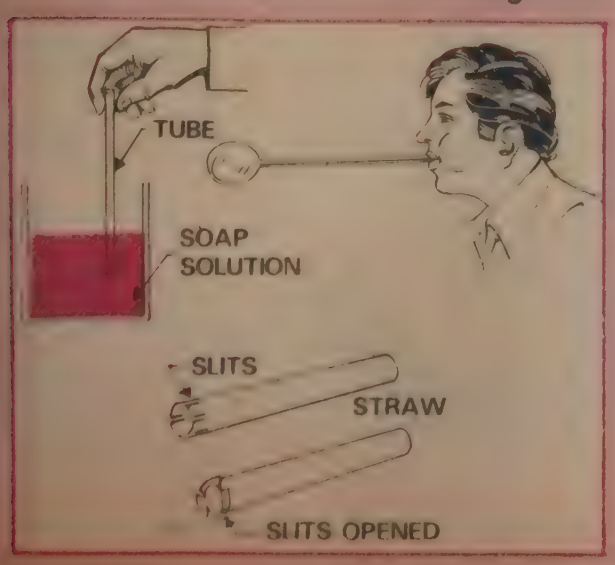
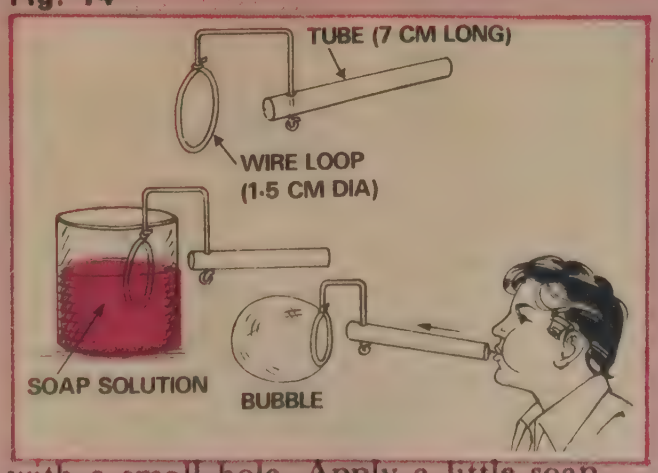


Fig. 14



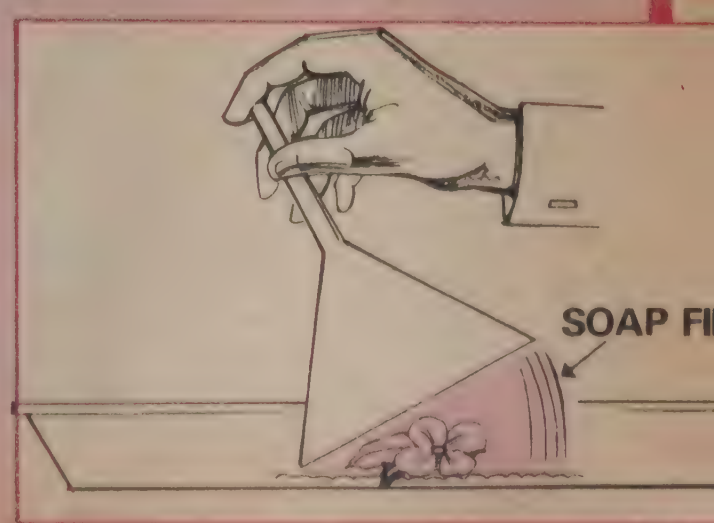
You may also use paper drinking-straws to blow fairly large-size bubbles. Slit one end of the straw in four cuts and open the slits.

Or else, you may make a device using soft wire and a polythene tube. Prepare a loop with the wire and fix it to the tube. Take soap solution in a small container and dip the loop in it. Now blow or just drag the loop through the air. You will see bubbles streaming through the air.

Flower in a bubble

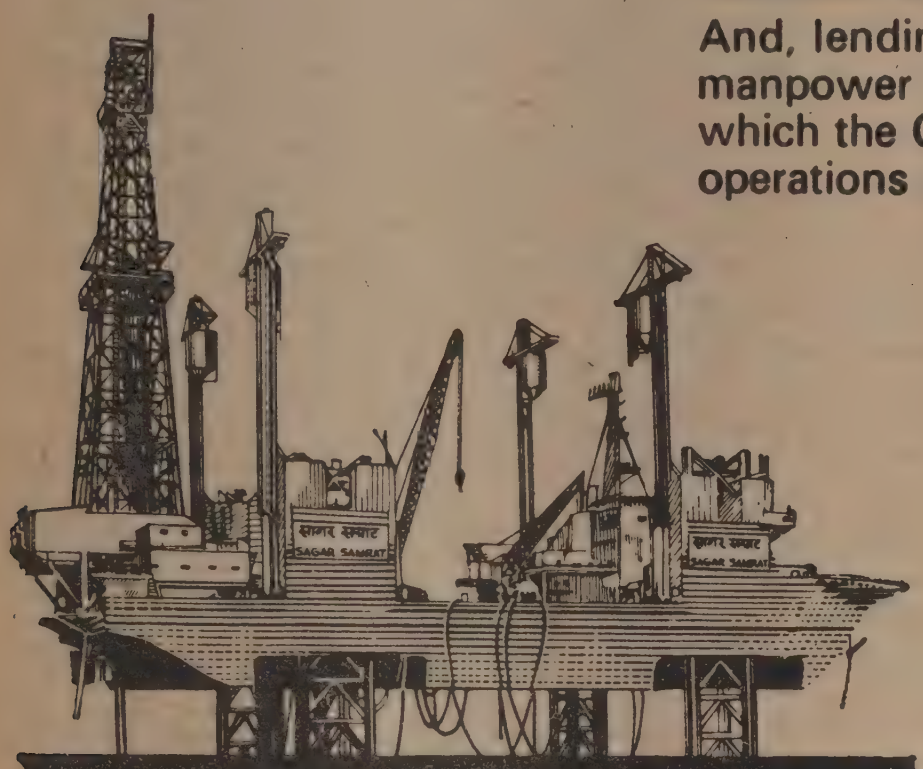
Pour the soap solution into a dish and place a flower in the centre and cover it with a glass or plastic funnel. Lift the funnel slowly, simultaneously blowing through the narrow end to get a large bubble. Tilt the funnel to release the bubble gently and remove the funnel. The flower will be under the soap film dome.

Fig. 15



The people at ONGC fulfil another pledge—by producing 32,000 barrels of crude per day at Bombay High—in just three years from the first oil strike. Within this short span of time, ONGC has also mastered a whole new technology.

By the end of 1977, ONGC hopes to double production of crude from Bombay High to nearly 80,000 barrels per day.



On shore, too, ONGC has intensified its activities. There is a country-wide search for new oil fields. Simultaneously, all-out efforts are being made to strengthen indigenous capability—by developing expertise, personnel and equipment.

The strength to achieve this lies in the 23,000 dedicated men who constitute ONGC. And in the fact that, by its own constitution, ONGC is committed to carry on a ceaseless search for oil.

And, lending strength to its manpower is the manner in which the Commission's operations are constituted.

All activity is grouped under four different regions—Western, Eastern, Central and Off shore.

Happenings in every site, in every region are communicated to the Headquarters at Dehra Dun. Which, in turn, steers these operations to desired objectives, through judicious amendments, as and when necessary.

All these constituent strengths have enabled ONGC not only to set ambitious targets, but also to achieve them. On shore as well as off shore.

And ONGC's success at Bombay High is just the preamble.

Oil & Natural Gas Commission
Tel Bhavan, Dehra Dun

Our strength is in our people

Oil flows
- the nation grows

ONGC

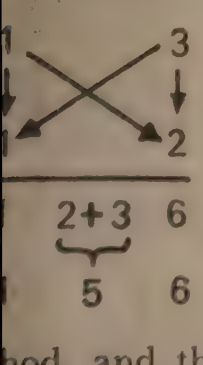
SAA/ONGC/605

Maths and the Vedas

THS or MAGIC? by Joseph
vse, Watkins Publishing, London,
6, p. 106, price not mentioned

his book is supposed to be an ntroduction to a bigger one, *c Mathematics* or "Sixteen simple hematical formulae from the as" written by Jagadguru mi Sri Bharati Krsna Tirthaji araja, Sankaracharya of Govar-na Matha, Puri, published in . In this latter book, the Jagad- is supposed to have uncovered e Sutras of the Vedas which, in , are said to offer short-cuts to e arithmetical and algebraic rations. However, the present or has taken no care to see if the as referred to are really in the as. The editor of *Vedic Mathe-cs* says (pp. 5 & 6), "The question rally arises as to whether the as which form the basis of this tise exist anywhere in the Vedic ature as known to us. But the *cism* (italics mine) loses all its force e *inform* ourselves of the *definition* Vedas given by Sri Sankaracharya self. . . . But this work of Sankara-rya deserves to be regarded a new Parisista by itself and not surprising that the Sutras tioned herein do not *appear* in the erto known Parisistas".

hus the book can hardly be called ic mathematics. And if one con-rs the topics covered, there is dly any need for present-day ents to know any of these except ome tedious piece of amusement. instance, the one-line method of tiplication is the same as the usual hod except that it is more difficult hase all the terms that would con-ute to any given place. It is neces- to memorise, in addition to the tiplication table, the table on p. 7 is book. Thus the usual procedure nultiplying, say 13×12, can be ten in one line as $1 \cdot 2 + 3 \cdot 6 = 156$. However, it is quite clear that to multiply large numbers, the contributions at any given place are much better displayed in the usual hod, and that is the reason why procedure has been adopted, e the alternative one-line method ssitates memorisation of the table.



he use of this method might have alright at a time when paper and pencil were not freely available and one had to carry out the operations in one's mind. If operations like multiplication are taught at present, it is not so much for doing these multiplications as to learn how to multiply if the necessity arises and also to inculcate the habit of doing some systematic work. However, as everybody knows, if one has to perform repeated multiplications, one hardly uses such methods, but, instead, uses tables, and instruments, including computers. Of course, it is quite another thing to banish this practice altogether and teach the use of computers or other instruments straightaway. Memorisation, practice, understanding and tools all have their role to play appropriate to the age group, and no single method should dominate to the general detriment of the student. It is only obstinate devotees of the so-called New Mathematics who would include an unreasonable number of steps in the name of understanding, actually reducing the students to computerised morons. A reasonable amount of tricks and short-cuts are often taught and appreciated by students.

Thus, most of the tricks mentioned in the book form part of the arithmetic or algebra texts in schools, e g, the Nikhilam method is an application of $(a - x)\ (a - y) = a^2 - a(x + y) + xy$, the application of which is usually done as an exercise. But it is hardly necessary to elevate it to the title of a method. Indeed, as the Jagadguru himself observes in his book (p. 85), "All these considerations (arising from our detailed, comparative study of a large number of examples) add up, in effect, to the simple conclusion that none of these methods can be of general utility in all cases, that the selection of the most suitable method in each particular case may (owing to want of uniformity) be confusing to the student and that this element of uncertainty is bound to cause confusion". Of course, the Jagadguru believes a one-line general formula can be given to perform such operations, but in that case, one does not understand why one should explain all these methods.

The only redeeming feature of this book is that it is written in a simpler style than *Vedic Mathematics* which is quite unreadable.

B. V. SINGBAL

[Dr. Singbal is with the School of Mathematics, Tata Institute of Fundamental Research, Bombay.]

Reactions in organic chemistry

REACTION MECHANISM IN ORGANIC CHEMISTRY by S. M. Mukherji and S. P. Singh, The Macmillan Company of India Ltd, 1976, 388 pp, Rs. 24

This is a good, modern book dealing with the various aspects of reaction mechanisms frequently encountered by students of organic chemistry. Beginning with the concept of atomic orbitals, types of organic reactions and reagents, as well as energy and stereochemical considerations, the authors have elaborated the subject in a conventional manner. The book should prove useful to both undergraduate and postgraduate students of organic chemistry of many of our universities. A noteworthy feature is the use of modern terminology such as the reference to the Diels-Alder reaction (p. 131) as an example of (4 + 2) cycloaddition.

The authors have also included chapters on organic photochemistry and pericyclic reactions. These topics are of comparatively recent origin and, in view of their growing importance and usefulness (specially the FMO method) in predicting the stereochemical courses of many reactions, no student of organic chemistry can afford to be ignorant of them. In fact, the two topics should form part of the MSc syllabi in organic chemistry in all universities.

There is a bibliography at the end of every chapter. In the last chapter, two references, *Pericyclic Reactions* by Gill and Willis and *Frontier Orbitals and Organic Chemical Reactions* by Ian Fleming could have been added. It is not clear why no reference is made to *Organic Chemistry* by Hendrickson, Cram and Hammond, which is an excellent book.

While adequate information is given about many reactions, little material is included on reactions like Michael addition, Meerwein-Ponndorf reduction and Dieckmann reaction. Students preparing for their examinations may have to seek detailed information on these from other sources.

The book is almost free from errors.

J. R. MERCHANT

[Dr. Merchant is Professor of Organic Chemistry at the Institute of Science, Bombay.]

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What are metallic glasses?

Three distinct forms of condensed matter are found in nature — crystals, glasses and uids. Crystals become liquid on lting and glass is essentially a super- oled liquid. And when a liquid is oled sufficiently slowly, the reverse melting — crystallisation — is nor- lly observed.

Metals and their alloys have nor- lly a crystalline structure in which atoms are arranged in a regular ay. Glasses differ from metals in nost every respect. They are brittle, quently transparent, good insula- s and resistant to corrosion. They ve a strong directional covalent nding whereas the metallic bond non-directional and collective. The oms in the latter generously donate fraction of their electrons in a sort mutual give-and-take — a sea of ctrons that gives both overall co- sion and easy electrical conduction. typical glass has an amorphous ucture in which the atoms, though nsely packed, are jumbled together th no apparent regularity in space g. 1).

Metallic glass is a new class of tallic material with a structure re characteristic of glass and with gularly non-metallic behaviour. nsidered unworthy of any detailed ention when they were discovered years ago, today they are creating metallurgical revolution, thanks to discovery of very promising me- anical, magnetic, electrical and rrosion properties, coupled with vanced production techniques. In th industry and universities, re- rch on them is already entering a ge of exponential growth.

How are metallic sses produced? Classically, much fore the advent of systematic metal- gy, it was known that metals are able of exhibiting properties other n those of their natural state by enching. The process involves freez- in non-equilibrium states in the crystals by simply plunging the heated metal into water, when cooling rates of the order of a few thousand degrees per second are readily attained. To produce metallic glass, quenching rates several orders of magnitude higher than those achievable in normal metallurgical practices are required to retain an amorphous phase.

The first metallic glass was produced by Klement, Willens and Duwey at the Engineering Materials Laboratory of the California Institute of Technology, USA, in 1960. They propelled small metal globules at a high velocity against cold surfaces. Quenching rates in excess of a million degrees a second were achieved in the process now termed " splat quenching ". The first specimens consisting of 75 per cent gold and 25 per cent silicon were a few microns thick and a centimetre or so in diameter. Deposition of metallic vapours on cold substrates (often cooled by liquid nitrogen), sputtering and electrodeposition are other methods of producing metallic glasses.

A US firm has, however, developed an ingenious system known as " drum quenching " for producing continuous ribbons of metallic glass (Fig. 2). While still in the liquid form, the hot metal is injected between counter-rotating drums that are continuously cooled. Commercially available ribbons are now being produced at the rate of about 2,000 metres per minute by this technique. In roller quenching, another technique, thin plates are being produced by rapid quenching of a continuous stream of liquid between two rotating wheels. Cost of production is considerably reduced in these techniques, since the otherwise expensive and energy-consuming stages such as casting, rolling and drawing, necessary when working with the solid state of the material, are by-passed.

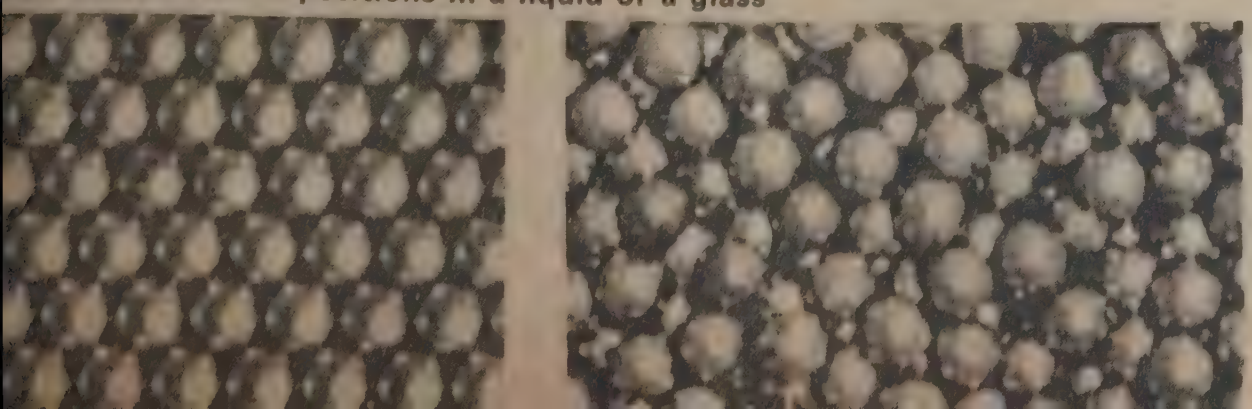
In terms of mechanical property, nearly all metallic glasses may be characterised as extremely hard, high tensile-strength materials; some of them are even stronger than stainless steel. They can withstand large plastic strains well in excess of 50 per cent, whereas common glass, even in the favourable form of thin filaments, cannot be strained in excess of one per cent. Strong and hard metals are rather brittle, so that the combination of great strength with ductility make metallic glasses suitable in many applications. The high corrosive resistance of these materials is a direct consequence of the homogeneous structure and is due to the absence of well-defined crystal boundaries and other defects on their surface. The other important properties of metallic glass are low ultrasonic attenuation and high electrical resistivity.

Fig. 2 Metallic glass ribbon (Photographs courtesy: *American Scientist*)

Metallic glasses show interesting magnetic properties. Such materials have been prepared to show most of the magnetic forms found in crystalline materials (dia-, para-, superpara-, ferro- and antiferro-magnetism). But it is the amorphous metallic ferromagnets which have attracted the most attention. Metallic glasses based on palladium, cobalt and silicon, or palladium, iron and silicon are ferromagnetic and can be easily magnetised and demagnetised. This property of ' magnetic softness ' suggests applications in magnetic memory devices and tape-recording heads, because it would facilitate rapid writing as well as erasure. The combination of soft ferro-magnetism, strength and high electrical resistivity renders these glasses ideal for use both in transformers and bistable switches.

K. A. NEELAKANTAN

. 1 The ordered structure (left) represents the crystalline phase found in metals ile the random close-packed arrangement (right) is a good representation of the tantaneous atomic positions in a liquid or a glass



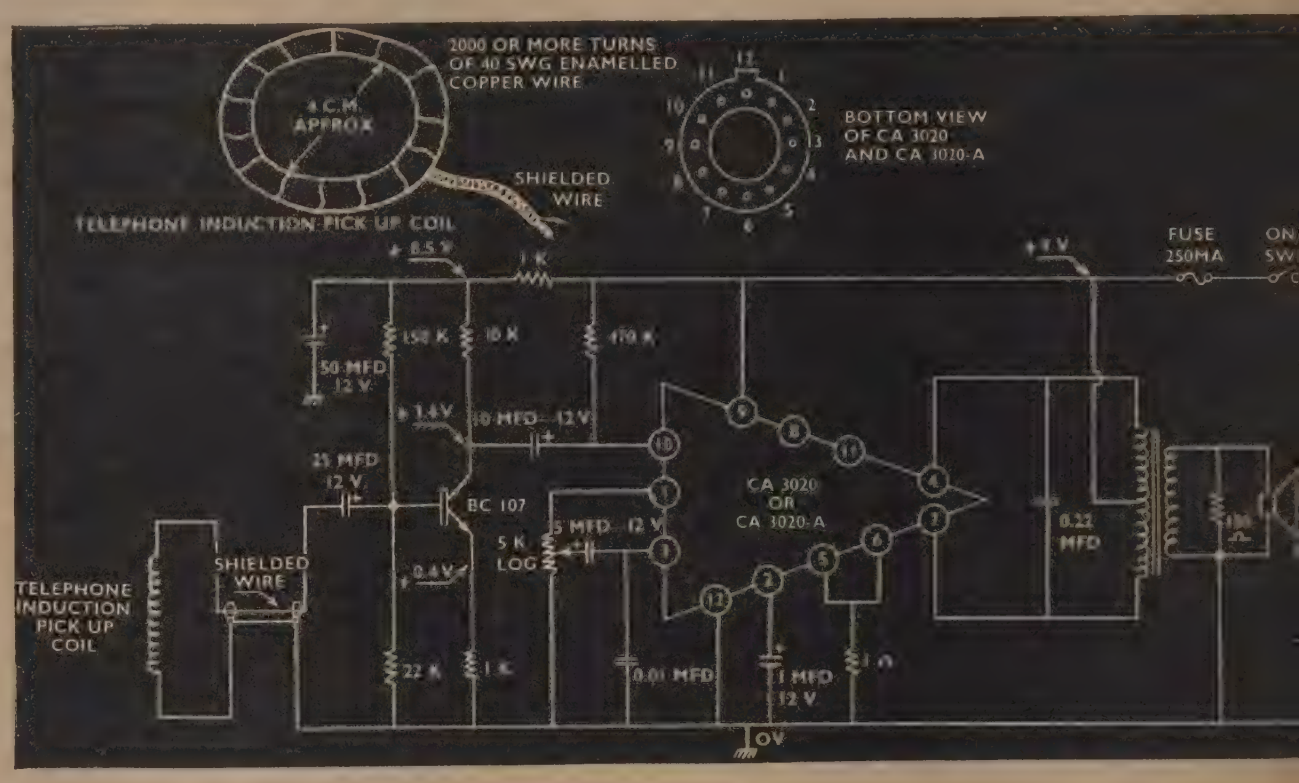
INTEGRATED CIRCUIT TELEPHONE AMPLIFIER

The integrated circuit telephone amplifier described here is similar in operation to the "Telephone Amplifier" (see SCIENCE TODAY, January 1976, p. 64). Instead of many discrete components, this new circuit uses an integrated circuit (CA 3020), one transistor (BC 107) and a few other components. The circuit given below is a slightly modified version of the "integrated circuit amplifier" (described in the February 1977 issue, p. 76), having, in addition, a single-stage common emitter-amplifier stage and an induction pick-up coil.

The induction pick-up coil is a flat toroidal coil. As such coils are not readily available in the market, you will have to make one yourself. Wind 2,000 or more turns of 40 SWG enamelled wire over a 4-cm diameter former. Neither the number of turns nor the diameter is critical, but the more the turns, the better. When the winding is complete, remove the former and tightly bind the coil with a self-adhesive tape and connect a shielded wire of about a metre length, as shown in the figure.

When the induction pick-up coil is kept in the vicinity of a telephone in use, the electromagnetic field produced by the current in the telephone wire, corresponding to the conversation, will induce corresponding electrical signals in the coil without any direct contact with the telephone wires. These signals will be amplified by the integrated circuit amplifier for reproduction through the loudspeaker.

When the construction of the unit is complete, check all the connections thoroughly, particularly of the integrated circuit CA 3020. Keep the volume control in its midway position and switch on the unit. Remove the handset from its rest position and keep it aside. Keep the pick-up coil close to the telephone and you will hear the



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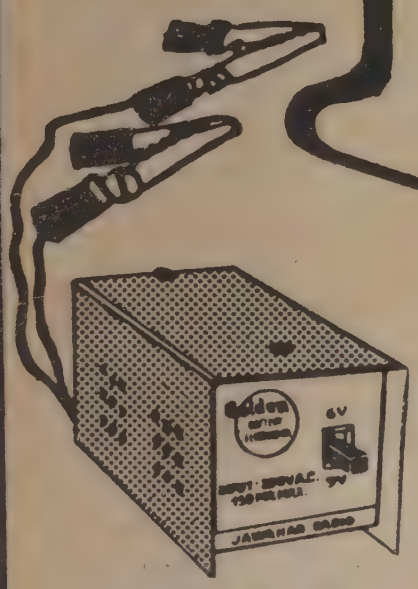

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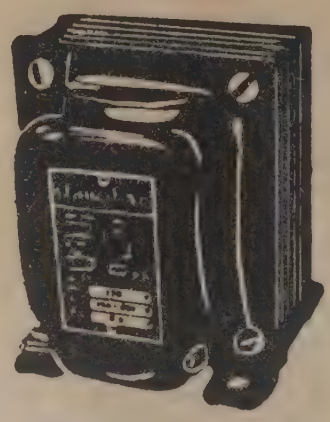

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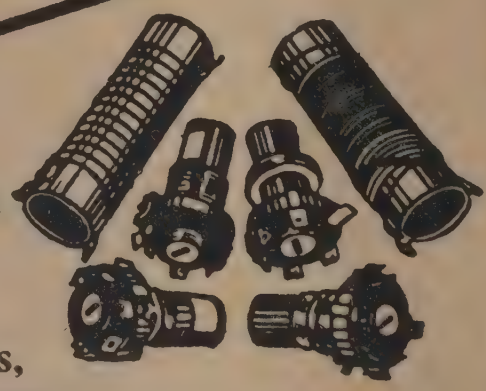

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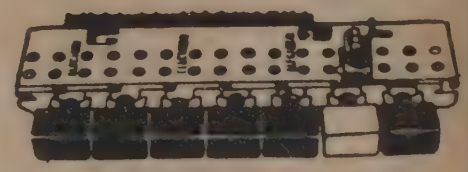

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l tone through the speaker. Now ve the coil on all sides of the tele- one until you hear the maximum l tone. Attach the coil in that parti- lar position to the telephone by an hesive tape. Now the unit is ready use. Dial a number and you will ar the conversation of both sides d and clear from the loudspeaker. hile doing this, keep the volume at e minimum possible, and also keep e mouth-piece of the handset away m, as well as turned in the opposite rection to, the loudspeaker; other- se self-oscillation will result.

u will need:

egrated circuit: CA 3020 or CA 3020 A
ansistor: BC 107
pacitors:

Electrolytic: 1 mfd 12 V 1 No; 5 mfd V 1 No; 10 mfd 12 V 1 No; 25 mfd V 1 No; 50 mfd 12 V 1 No.
Polyester or paper: 0·22 mfd 1 No; 01 mfd 1 No.
istors: (all half watt): 470 K 1 No; 0 ohms 1 No; 1 ohm 1 No; 150 K 1 No; K 1 No; 10 K 1 No; 1 K 2 Nos.
lume control: 5 K log. with switch
tput transformer: 500 mW. Pri: 100 to 0 ohms; Sec: to match the loudspeaker 1 No.
udspeaker with suitable enclosure: 1 No.
ttery: 9 volts (276 — P type) 1 No.
sc: Fuse 500 mA with holder, 40 SWG melled wire (200 gm, screws, wires), der, shielded wire, suitable enclosure.

ANIL V. BORKAR

BRAIN TEASERS

SPEED-KINGS: In a drive against overspeeding drivers, the traffic police challaned them and collected on-the-spot fines. Each overspeeding scooterist was charged Rs. 12·50, each car driver Rs. 20 and each heavy vehicle (bus or truck) driver Rs. 50. The total money collected in a forenoon session was Rs. 1,500, the major portion coming from heavy vehicle drivers. If the number of car drivers challaned was ten more than the number of heavy vehicle drivers, how many persons were challaned in all?

B. L. ARORA

TELEVISION PROGRAMME: A television centre decided to provide a real treat on five consecutive days during its anniversary celebrations. Instead of announcing the programmes in the usual way, it thought of a guessing game for viewers. It gave the following clues:

1. A Kannada movie will be shown on the last day.
2. A sarod recital will be immediately after the scientist's interview.
3. A social skit will be on the first day.
4. A professor's interview will follow the historical skit on the Gujarati movie day.
5. A shehnai programme and a science fiction skit will be on the same day.
6. A Tamil movie will be preceded by the music director's interview.
7. A Biblical skit and a Hindi movie will be on the sitar day.
8. A minister's interview will be on the Marathi movie day, but will be days earlier than the music director's interview.
9. A flute programme will be on the day following the violin day.
10. An editor will be interviewed on the third day.
11. A mythological skit will be telecast on one day.

Can you work out the entire programme?

V. A. SHENAI

(Solutions next month)

Solutions to last month's brain teasers

Badminton champ

The person who had stood third would never have mentioned that she came third because she had made both false statements. Latha said she stood third, which implies that she was lying; she could not have been first either, because she lied about her being third. Hence, she stood second. But Sujata said Amrit stood second, which again is a false statement because we have just seen that Latha came second. Now, Sujata couldn't be first as she had lied about Amrit being second, hence Sujata stood third and Amrit came first.

Tempos and cars

If all the engines belonged to tempos, there would have been $45 \times 3 = 135$ tyres. But there were 150 tyres, i e, an excess of $150 - 135 = 15$ tyres. Since a car has one more tyre than a tempo, there must have been 15 cars, and hence there were 30 tempos.

STATEMENT ABOUT OWNERSHIP AND OTHER PARTICULARS ABOUT "SCIENCE TODAY"

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11. Miss Nandita Jain — through her father, natural guardian Shri Ashok Kumar Jain, 6, Sardar Patel Marg, New Delhi.
12. PNB Finance Limited, B/45-47, Connaught Place, New Delhi 110 001.

I, Shreekrishna Govind Joshi, hereby declare that the particulars given above are true to the best of knowledge and belief.

te: 28th February 1977

S. G. JOSHI
Signature of Publisher

next month

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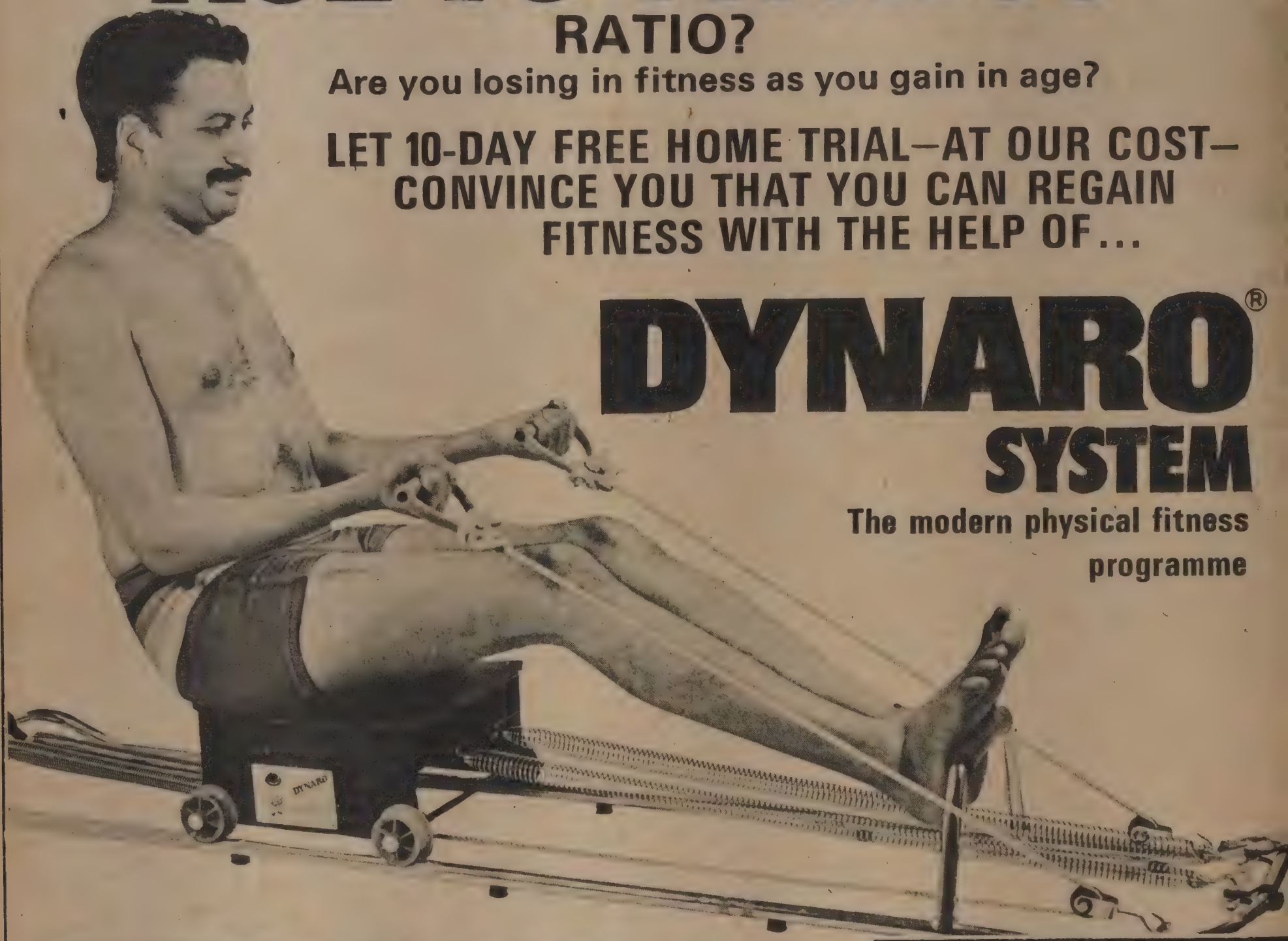

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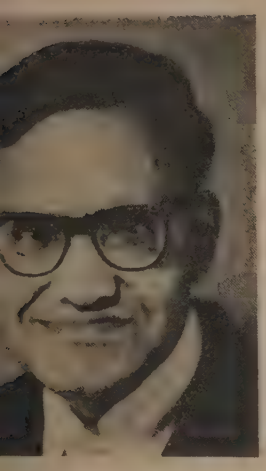
AWARDS & APPOINTMENTS

Dr. Jain heads IARI



Dr. H. K. Jain, has taken over as Director of the Indian Agricultural Research Institute (IARI), New Delhi. Dr. Jain, who headed the Genetics Division of the Institute, succeeds Dr. A. B. Joshi, who has been appointed Vice-Chancellor of the Mahatma Phule Krishi Vidyapeeth in Maharashtra.

Dr. R. S. Murthy, Chief Soil Survey Officer, IARI, has been appointed Director of the National Bureau of Soil Survey and Land Use Planning, newly set up by the IARI at New Delhi.

epublic Day honours for 15 inventors

ifteen inventors have been awarded a total of Rs. 26,000 by National Research Development Corporation of India on Republic Day for their inventions. The top honours have e to two groups — Dr. Krishna Lal, Mr. D. R. Pahwa, Mr. Vijay nar and Mr. Keshav Aggarwal of the National Physical Labo- ry (NPL), New Delhi, for "improvements in Lang camera the X-ray supply systems used for studying the crystal cture"; and Dr. Vishwanath Bindal, Mr. Vinod Kumar Gogia Mr. Gulshan Kumar of NPL, and Dr. M. Venkateshwarlu of Electronics Corporation of India Ltd, Hyderabad, for "im- vements in three types of conventional probes for ultra- ic non-destructive testing of materials and components". e two groups receive Rs. 6,000 each.

he other award-winners are: Mr. Baskarapandian of Metal wder Co Ltd, Madurai, Rs. 5,000, for a process for developing d bronze powder in different shapes and grades; Dr. B. S. Das, anagore Jute Factory Co Ltd, Calcutta, Rs. 2,500, for a cess of manufacturing boards from jute sticks and jute fibre, cultural and industrial wastes; Dr. K. Nageswara Rao, National ds Corporation Ltd, Vijayawada, Rs. 2,000, for a seed treator ch automatically releases a pre-determined quantity of mical; Mr. Zafar Elahi Shaikh, Metereological Department, w Delhi, Rs. 2,000, for conversion of forecast chart into ched tape for teleprinter transmission; Mr. Jayant B. hi, New Delhi, Rs. 1,000, for a cervical goniometer, for ermining the range of movements at the cervical spine; M. P. George, Birla Institute of Science and Technology, ni, Rs. 1,000, for a phase sequence indicator; and Mr. N. S. haye, BARC, Trombay, Rs. 500, for developing a set of cially designed plugs, sockets, adapters and other accessories. ides, Mr. Jagannathan of Integral Coach Factory, Madras, ives a certificate of merit for a self-centering chuck used for chines. He has nine other inventions to his credit.

aching aids in physics

or the second time, no entry has qualified for the first prize he 1976 Hari Om Ashram Prerit Dr. K. R. Ramanathan Awards teaching aids in Physics conducted by the Indian Physics ociation. The award was instituted in 1975. The second prize of 1,000 goes to Dr. Somnath Datta, of the Regional College of cation, Mysore, for his device which helps visually explain olems in electrostatics using membranes. Dr. Datta's demon- tion of angular momentum through a horizontal top and allied ces had won him the third prize in 1975.

r. S. Daniel Sam, of the Hyderabad Public School, who ged the second prize in 1975, has again received a prize this — the third prize of Rs. 500 for a simple harmonic motion which traces the simple harmonic motions produced by a cally oscillating spring and a pendulum on a paper tape. H. P. Lohumi, of Kathgodam, Nainital District, UP, has also a third prize of Rs. 500 for an aid to explain the refractive x of liquids by a double box method. Besides, three other ces have won consolation prizes. These are: (i) a magnetised e to demonstrate the basic principles of magnetism by S. C. Soni of Udaipur, Rajasthan, (ii) a telescope with ole eyepiece by Mr. S. D. Tase, Applied Mechanics Depart- t, Bhagubhai Mafatlal Polytechnic, Bombay, and (iii) an aratus to show Fleming's Left Hand Rule by Mr. Sharad ndra of the State Institute of Science Education, Udaipur.

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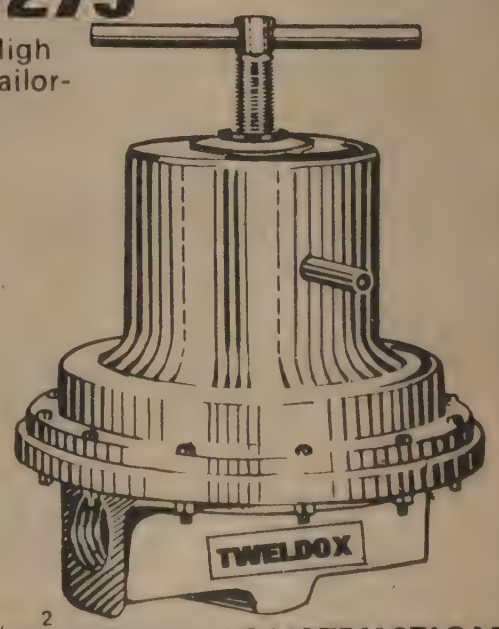

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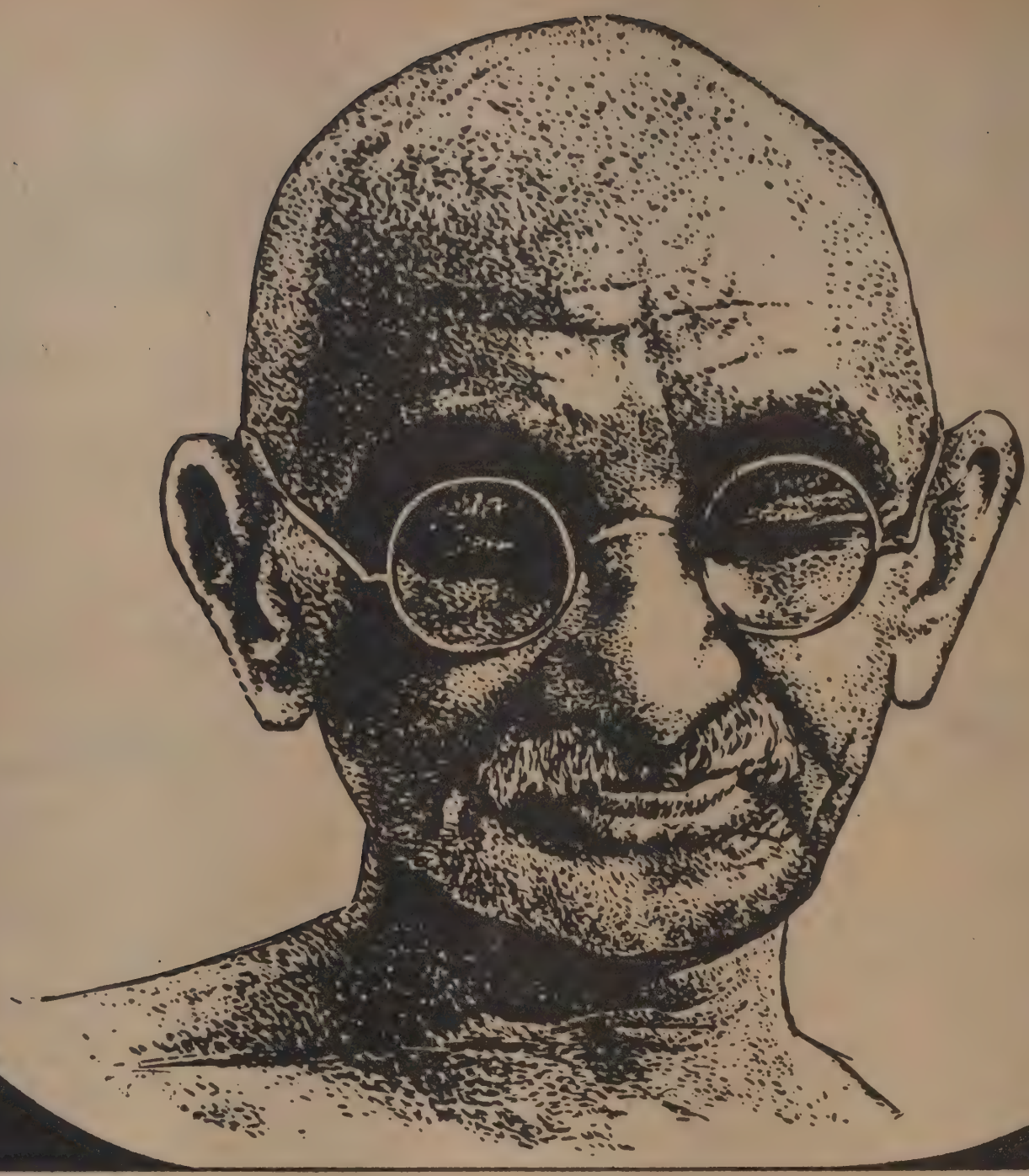

"Much of the deep poverty of the masses is due to the ruinous departure from Swadeshi in economic and industrial life."

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be Indian, buy Indian

davp 76/532

Did Space Explorers Visit Ancient Egypt?

Recent theory in Archaeology suggests that visitors from outer space landed in Egypt in prehistoric times.

Evidences such as paintings of space-ships, helmeted creatures, curious coincidences in the matching of the Pyramid's dimensions with distances between the planets and the sun and still inexplicable engineering feats involved in building the Pyramids are salient points for this theory.

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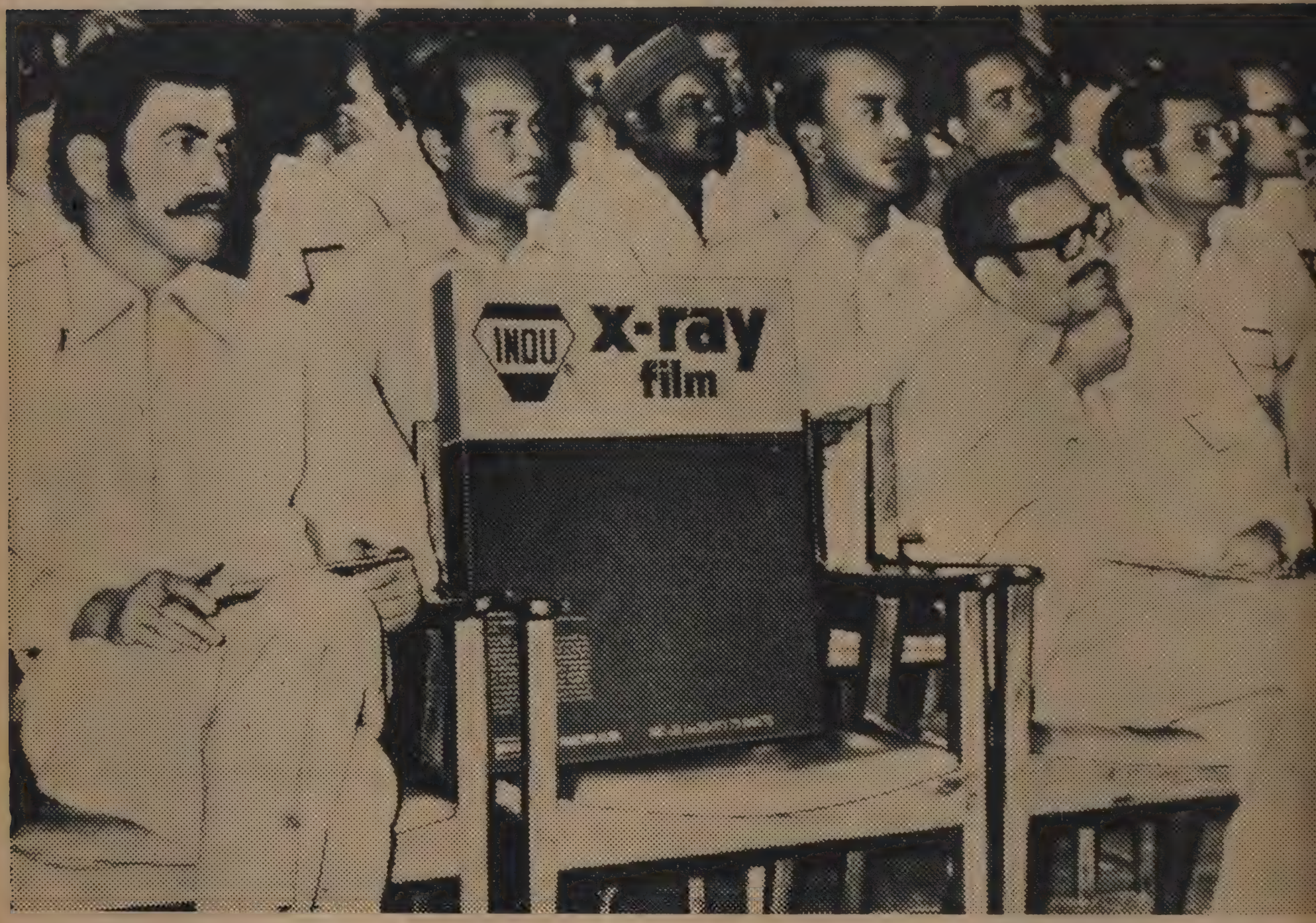

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10 July 1976

GARLIC THERAPY

Scientists have found that the active healing factor in garlic is a chemical called "allicin". Unlike commercial anti-biotics which destroy friendly bacteria along with the virulent ones, "allicin" wipes out only the dangerous ones- by suffocating them. Garlic, if taken regularly, is claimed to ward off colds, bring high or low blood pressure back to normal, quell indigestion and remove pimples. It can also cure colds.

Eve's Weekly

July-17-1976

AYURVEDA IN YOUR HOME

Suresh Chandra Chaturvedi

GARLIC

Regular use of garlic helps the digestive system and removes gas and constipation. It controls blood pressure, blood cholesterol and heart diseases. It increases the blood, cures chronic cold and cough and gives relief in dry piles and hiccups,

Gastric troubles are cured by taking garlic every day. A small piece of garlic is useful in rheumatism, arthritis, backache, paralysis and facial paralysis.

THE TIMES OF INDIA

BOMBAY, DEC., 3-1976

Eat Garlic and Cut Cholesterol

NEW DELHI, December 2: A medical study has revealed that garlic is effective in reducing blood cholesterol. Cholesterol is fatty substance whosedeposition inside blood vessels leads to "atherosclerosis" and eventually to heart attack. An experiment by Dr. R.C. Jain, patholagist at the University of Benghazi in Libya has now shown that garlic reduces the cholesterol level.

He did the experiment on rabbits which he fed with a diet containing large amounts of Cholesterol for 16 weeks. Their aorta (main blood vessel) and liver were deposited with cholesterol but after giving them garlic, he noticed that the fat dissappeared and the blood cholestrol came down. Dr. Jain has reported the results of his experiment in "The Journal of Indian Medical Research". How exactly garlic brings down cholesterol level is however, not clear, Dr. Jain said-Samachar.

SUNDAY STANDARD

(Incorporating The Sunday Indian Express)

Vijayawada, Sunday October 31, 1976

Raw Garlic is anti-bacterial

NAINI TAL Oct. 29 (Samachar)

Raw garlic possesses anti-bacterial property against a number of micro-organisms Including those which are resistant to commonly used anti-biotics. This is revealed in researches conducted at the Pantnagar University. According to the researchfindings, anti-bacterial property of garlic is lost on boiling.

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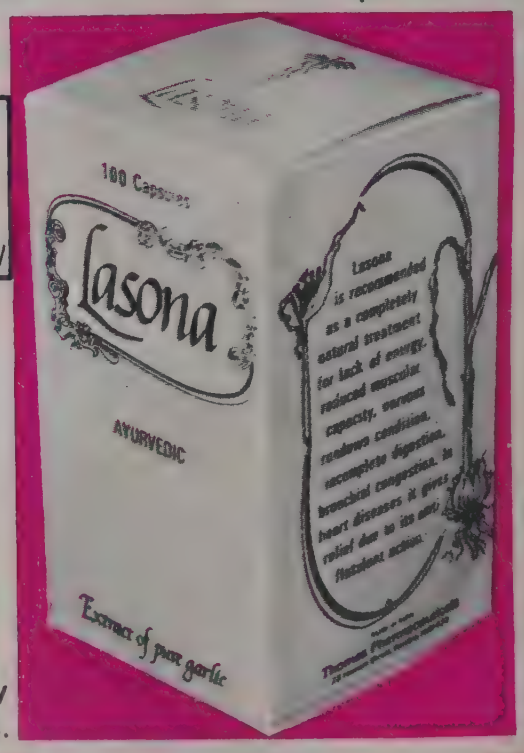
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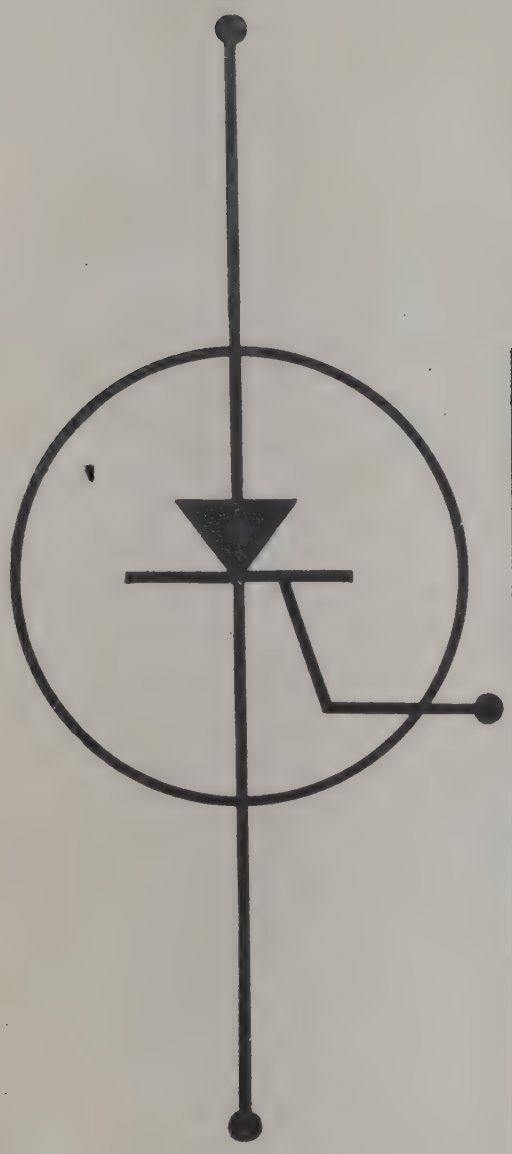

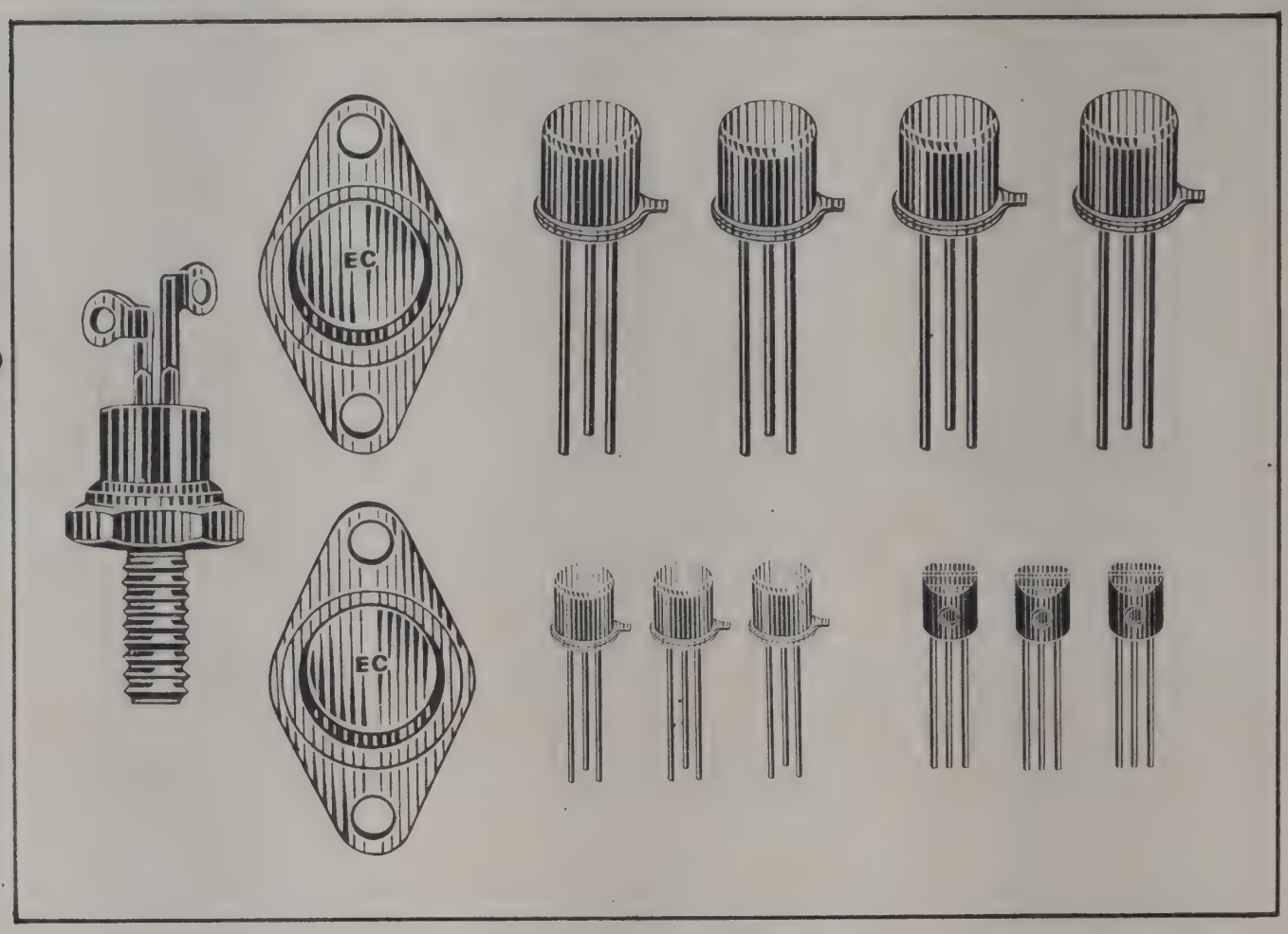

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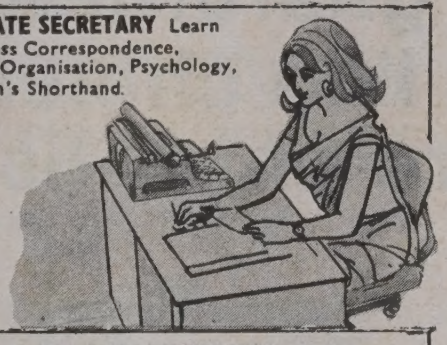

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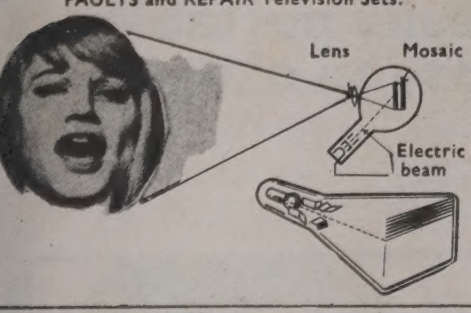

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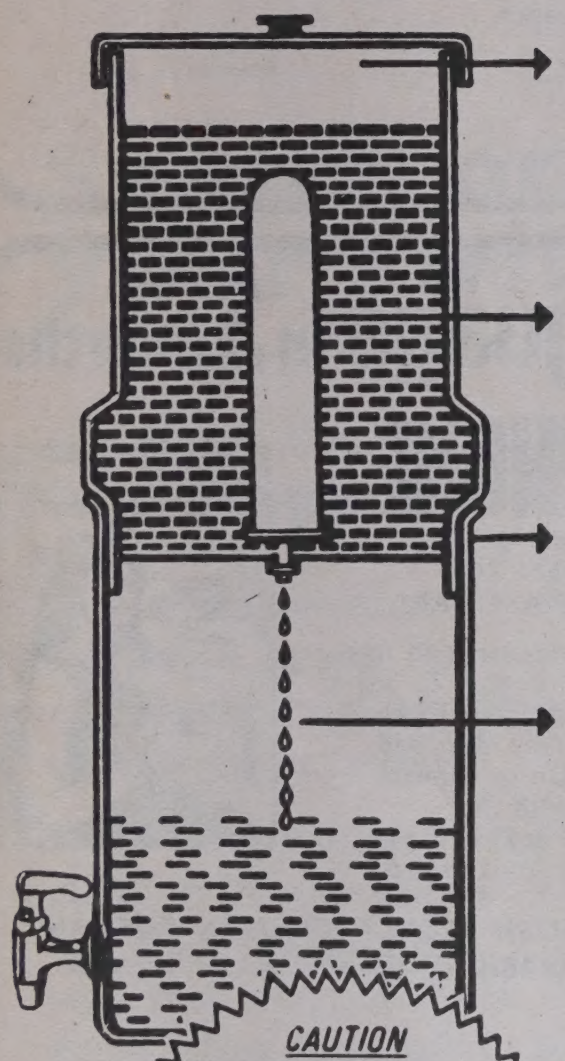

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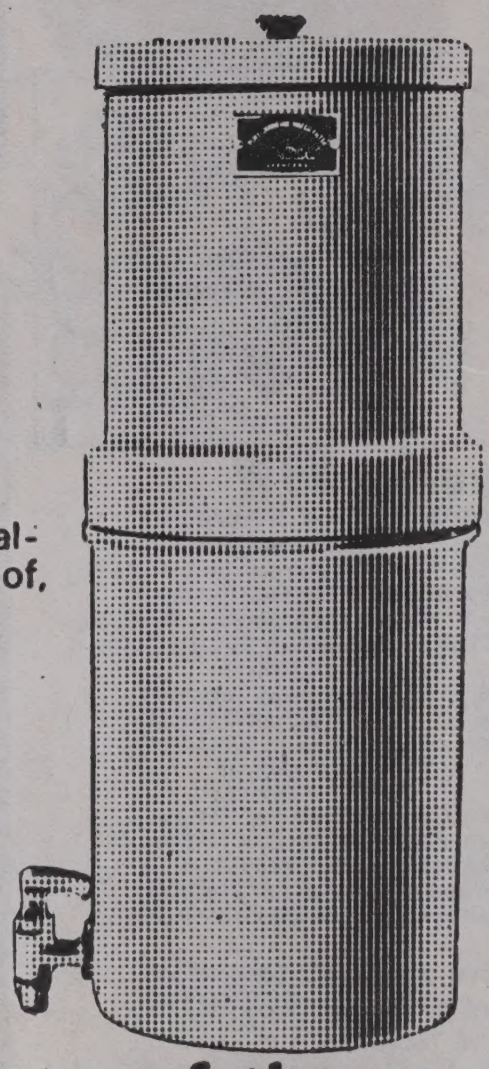

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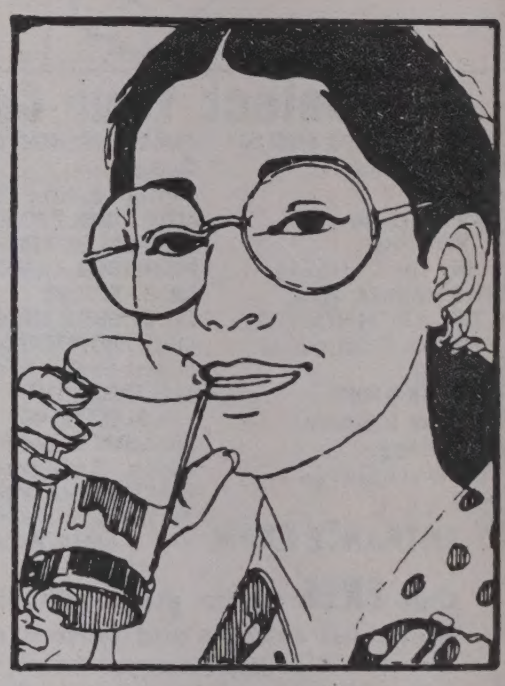

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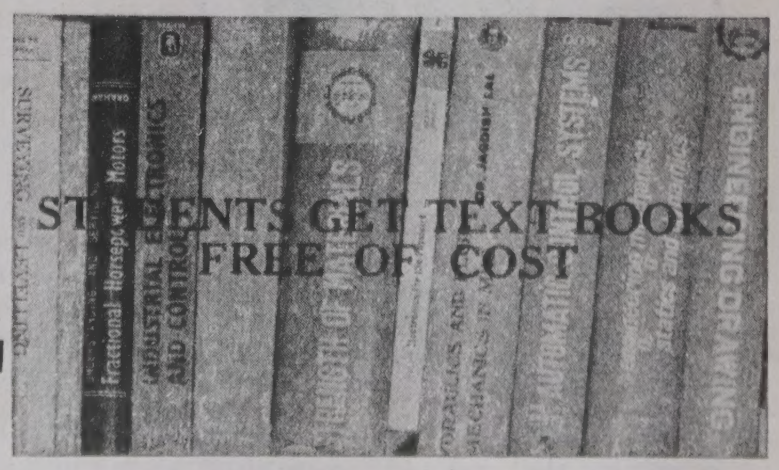

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FACTS YOU'D LIKE TO KNOW ABOUT THE PHARMACEUTICAL INDUSTRY

The pharmaceutical industry in India has a record of performance matched by few other industries. In terms of quantity and quality of growth, it is in the front rank of India's science-based industries, producing almost all essential medicines and meeting the country's requirements of finished products in full and of bulk drugs very substantially.

Among the developing countries India has the distinction of having the largest and most modern pharmaceutical industry, according to the rating of the United Nations Industrial Development Organisation (UNIDO). Here are the dimensions of growth in brief:-

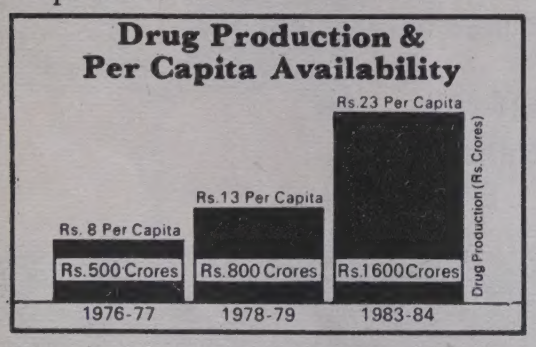
1948 Vs. 1976—Progress Made

(Rs. Crores)

	1948	1976
Capital Investment	24 (1952)	225
Production	10	500
Bulk Drugs	18 (1965)	100
Exports	1.27 (1963-64)	26
Research & Development	Negligible	8

The present production of drugs in the country, valued at Rs. 500 crores, works out to Rs. 8/- per annum on a per capita basis. Even if production were to be increased to Rs. 1600 crores by the end of the Sixth Plan (1983-84) that is, more than three times the current output, it would hardly be sufficient for a per capita availability of drugs of Rs. 23/- per annum as by then our population would have also increased.

The fact is that the country just does not produce enough drugs to go around; nor will it be able to meet the demand in full in the 5th and 6th Plans, if 50% of the population becomes regular consumers of modern drugs instead of 20-25% at present.



Total Management Capability

The pharmaceutical industry has the capability–technological, financial, managerial, in fact, of total management—to achieve the required production provided the right policies are adopted and a suitable operating environment or growth climate is created.

There are four major policy questions that are fundamental to the growth of the industry on healthy lines. These cover (i) production (ii) pricing (iii) research and development and (iv) technology.

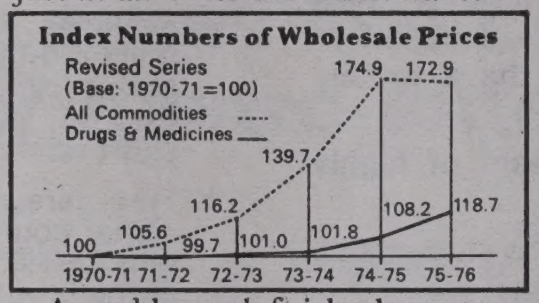
Production

Undoubtedly higher production of both bulk drugs and finished products is the most important national need today. There is an urgent need to redefine our priorities and reframe our policies with a view to expediting the process of full utilisation of capacities to maximise production.

Pricing

Drug prices in India are among the lowest in the world. Expert bodies and official committees of enquiry have decisively confirmed this fact. Yet the vast majority of our people cannot afford to buy the medicines they need. This is a clear indication that drug prices are not high but that, unfortunately, the purchasing power of our people is low which in turn is a reflection of the low level of our economy.

The industry's record in holding the price line of drugs is exemplary. According to the Government price index, drugs are among the very few commodities in which inflation has been minimal. This despite the fact that the drug industry has suffered from an escalation in costs just as all other industries have.



A stable and fairly long-term pricing policy for both bulk drugs and formulations is basic to the healthy growth of the industry. Such a policy should ensure a fair price—fair to the consumer as well as to the producer.

Research & Development

In all the areas of R&D—basic research, process research and improvements, product development, formulation, packaging and import substitution research—the pharmaceutical industry has an excellent record. Look at the facts. The industry's R&D spending is 2% of its sales turnover. This compares very favourably with the R&D expenditure of 0.06% by all industries in the country. However, compared to the industry in the developed countries, our R&D expenditure would appear to be small. But then R&D is directly related to the size of operations and the level of profits. The pharmaceutical industry in India, and the units comprising it, are small not only by international standards but by Indian standards as well. However, this situation is bound to change. As the industry grows and with it the size of the individual units, research and development relevant to the diseases and conditions prevalent in India would grow apace.

R & D Expenditure-A Comparison

	% of turnover
Drugs & Medicines	2.0
Textiles	0.1
Rubber Products	0.6
Chemicals & Chemical Products	0.1
Engineering & Machine Building	0.08
All Industries (Average)	0.06

Technology

The pharmaceutical industry, more than any other industry, is international in character and operations. Disease knows no national boundaries and the search for new knowledge and new agents to combat disease and relieve human suffering are truly international in scope and coverage. If it were not for the international character of pharmaceutical research, modern therapeutics would be very much poorer.

Self-reliance in technology is one of our major national goals. With its large scientific infrastructure and technical manpower our country is now well set on the road to technological self-reliance in several fields, including pharmaceuticals. However, self-reliance can be viewed only in a relative sense—relative to the time and situation of each industry. A degree of self-reliance is a feasible and desirable national goal but complete self-reliance is not possible; nor is it desirable even for the most developed country today. The international orientation of the industry also facilitates the inflow of new products and new technologies which in turn strengthens our own technological capabilities.

The very fact that even such developed countries as the United Kingdom and Japan, who have obtained a high degree of technological competence, not only allow but even encourage collaboration by international companies from other countries indicates that such collaboration is necessary and is in the best interest of the industry and of the people in these countries.

At the Cross-Roads

The pharmaceutical industry in India today stands at the cross-roads. It is a vital segment of the national economy. Its products and services are an essential input in our health care programme. Let us therefore adopt such policies and attitudes that will stimulate and sustain the growth of the industry. So that it is enabled to make available modern drugs of the highest standards of quality to all our people where they are needed, when they are needed.

If you would like to have more information and data about the pharmaceutical industry, please write to:

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